DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TM 5-277

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PANEL BRIDGE, BAILEY TYPE, M2



DEPARTMENT OF THE ARMY *APRIL 1948*

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TM 5-277, Panel Bridge, Bailey Type, M2, is published for the information and guidance of all concerned.

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For explanation of distribution formula see TM 38-405.

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PART ONE
GENERAL

CHAPTER 1
SCOPE

1. Purpose

This manual describes the normal and special construction and uses of the M2 panel bridge and includes a brief discussion of the M1 and British panel bridges in the appendixes. It is to be used both as a reference handbook and for training purposes.

2. Organization of Manual

a. M2 BRIDGE. The subject matter is divided into four main parts.

(1) Part one contains the introduction and covers the use of panel bridges.

(2) Part two covers the normal construction and use of the M2 panel bridge.

(3) Part three covers all phases of special construction, including panel crib piers, as well as special bridge construction using M2 equipment.

(4) Part four covers special launching methods required when launching sites are restricted or launching equipment is not complete.

b. OTHER BRIDGES. Detailed technical data and a brief description of the M1 fixed panel bridge and the British Bailey bridge are given in the appendixes at the rear of the manual.

3. Related Publications

Certain details relating to the tactical use of the bridge, the panel bridge company, and the British Bailey bridge which are not covered in this manual can be found in the following publications: bridge tactics are covered completely in FM 5-6; the organization and equipment of the panel bridge company are given in T/O & E 5-287; details of the British Bailey bridge are given in the British publications listed in appendix IV.

CHAPTER 2

USE

Section I. TYPES OF STRUCTURE

4. General

Panel bridge equipment can be used to build fixed bridges and panel crib piers and towers. Other special structures such as floating bridges, suspension bridges, retractable bridges, and mobile bridges, can be built using special British parts.

5. Normal Construction

Panel bridge equipment is normally used to erect fixed simple-span through-type bridges from 30 to 210 feet long. The bridge can be assembled to meet varying conditions of span and load.

6. Special Construction

a. BRIDGES. Panel bridge equipment can also be used to build two-lane through type bridges, deck type bridges, railway bridges, bridges on piers, and floating bridges.

b. PIERS. Panel crib piers and towers up to 70 feet high can be built with panel bridge equipment and special crib-pier parts.

c. EXPEDIENTS. Panel bridge equipment can also be used in whole or in part to build many structures, such as causeways, box anchors, towers for floating bridge cables, and loading hoppers and gantries.

Section II. SITUATIONS

7. General

The panel bridge is used to carry both division and army loads as a tactical bridge in the initial assault and in the build-up, and as a line of communications bridge.

8. Tactical

a. INITIAL ASSAULT. The panel bridge is not generally used for the initial assault except in special situations. In these special situations, the use of armored devices for launching is required.

b. BUILD-UP. The fixed simple-span panel bridge is most often used for the build-up. However, when a long, heavy simple-span bridge is needed, it is sometimes more economical of time and material to build a bridge on piers, especially if partially demolished piers already exist.

9. Line of Communications

The panel bridge is an excellent line of communications bridge. It can be built as a through type bridge, both fixed and floating, and as a fixed deck type bridge.

a. THROUGH TYPE BRIDGE. (1) *Fixed.* The fixed through type bridge can be built as a simple or multiple span bridge of one or two lanes. It is especially useful when piers already exist from a demolished bridge. The through type bridge can also be used for short-span railway bridges.

(2) *Floating.* The panel bridge on barges is used when a floating bridge of high capacity is required for crossing a wide swift stream or tidal estuary. This bridge can be built with one or two lanes depending upon the capacity of the barges.

b. DECK TYPE BRIDGE. When a single- or two-lane bridge with unlimited deck clearance is required, the deck type bridge can be used. This bridge has a high capacity and can be used as either a highway or railway bridge.

PART TWO

NORMAL CONSTRUCTION

CHAPTER 3

GENERAL DESCRIPTION

10. Component Parts

The panel bridge is a through type truss bridge, the roadway being carried between two main girders (figs. 1, 2, and 3). The trusses in each girder are formed from 10-foot panels pinned end to end. Transverse floor beams, called transoms, are clamped to the bottom chords of the trusses and support stringers and decking. Sway braces between the girders provide horizontal bracing, rakers between the trusses and transoms keep the trusses upright, and bracing frames and tie plates between the trusses provide lateral bracing within each girder. The bridge set contains 34 different items and 28 different tools. These are described in detail in chapter 5. Since all parts can be man-handled, the bridge can be built by manpower alone.

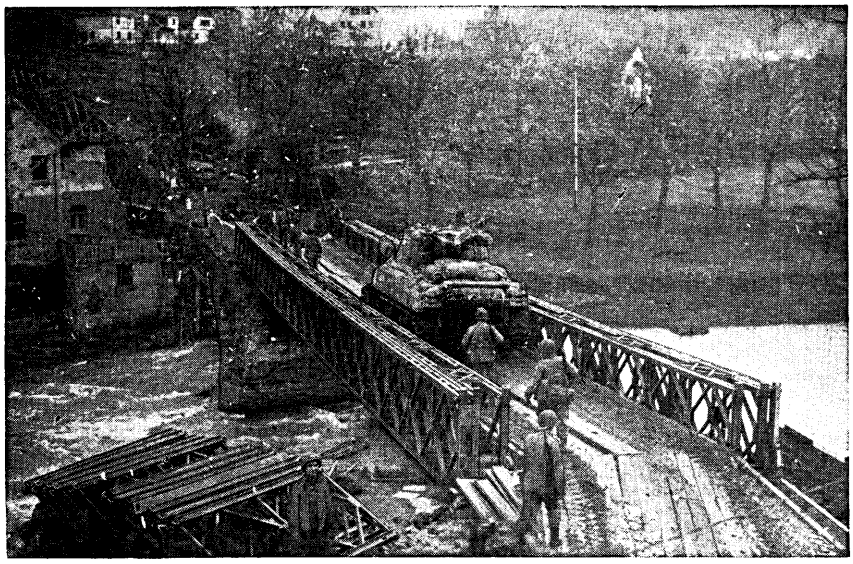


Figure 1. M4 tank crossing 110-foot, triple-single M1 panel bridge over Roer River at Heimbach, Germany.

11. Materials

The decking, called chess, is wood. Panels, end posts, transoms, and ramps are a low-alloy, high-tensile steel. All other parts are carbon structural steel. All joints in the parts are welded.

12. Trusses

The main girders on each side of the bridge can be made from a single truss or from two or three trusses side by side. For greater strength, a second or third story of trusses can be added. The upper stories are bolted to the top chord of the lower story. Only the following types of truss construction (fig. 4) can be used:

Type	*Usual Nomenclature*	*Abbreviation*
Single-truss, single-story	Single-single	SS
Double-truss, single-story	Double-single	DS
Triple-truss, single-story	Triple-single	TS
Double-truss, double-story	Double-double	DD
Triple-truss, double-story	Triple-double	TD
Double-truss, triple-story	Double-triple	DT
Triple-truss, triple-story	Triple-triple	TT

A single-truss, double- or triple-story bridge is never built because it would be structurally unstable. All triple-story bridges with deck in bottom story are braced at the top by transoms and sway braces which are fastened to overhead bracing supports bolted to the top chords.

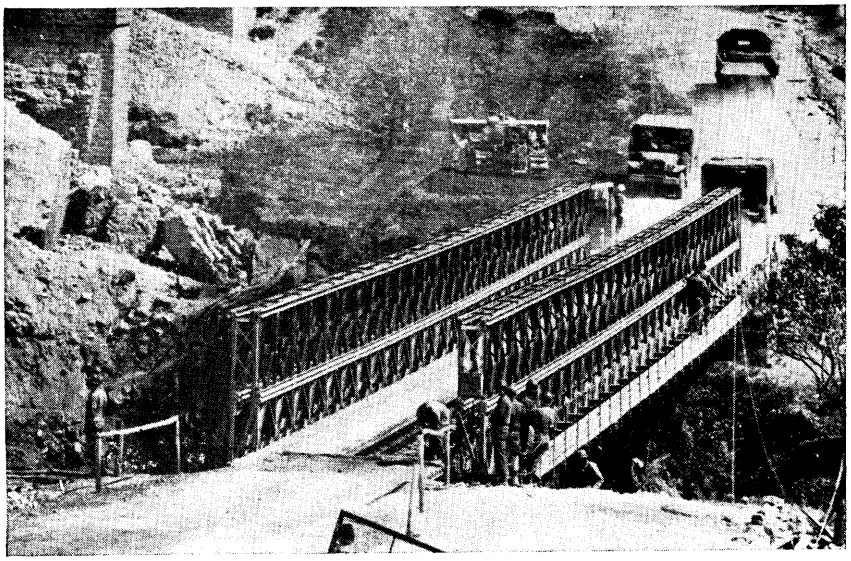
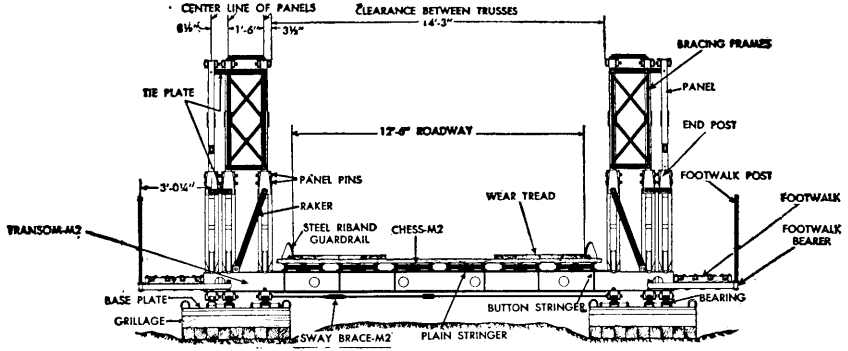
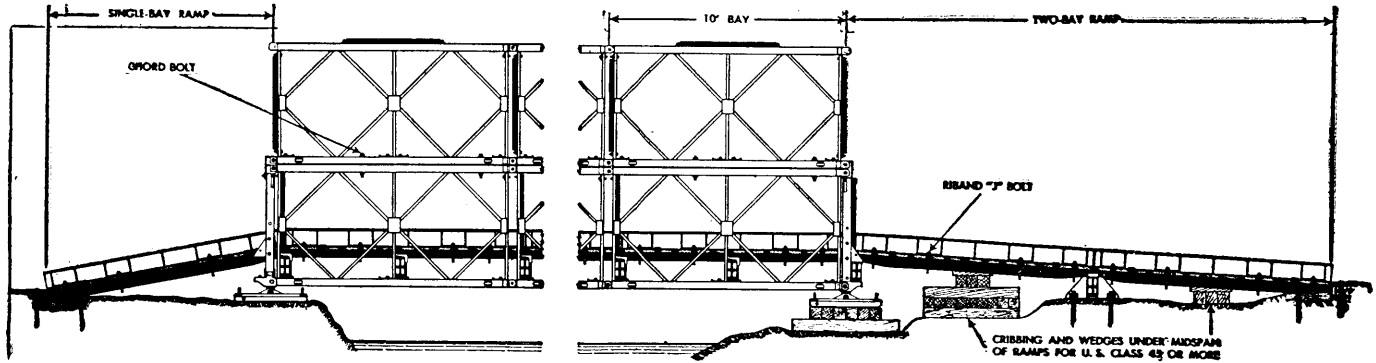


Figure 2. Truck traffic over 140-foot, double-double M1 panel bridge in Sessa area, Italy.

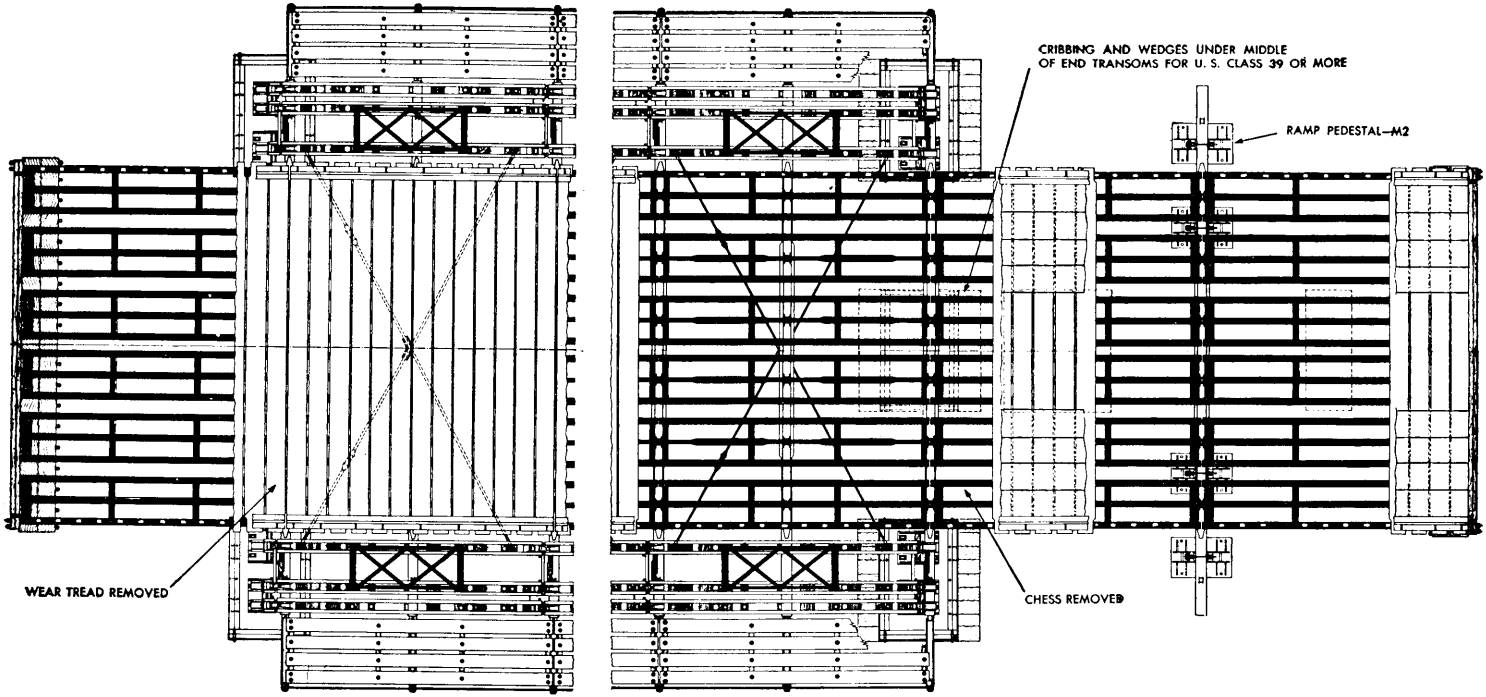


END VIEW (RAMP REMOVED)



ELEVATION (FOOT WALK REMOVED)

Figure 3. Fixed panel bridge, Bailey type.



PLAN

Figure 3. Fixed panel bridge, Bailey type—Continued.

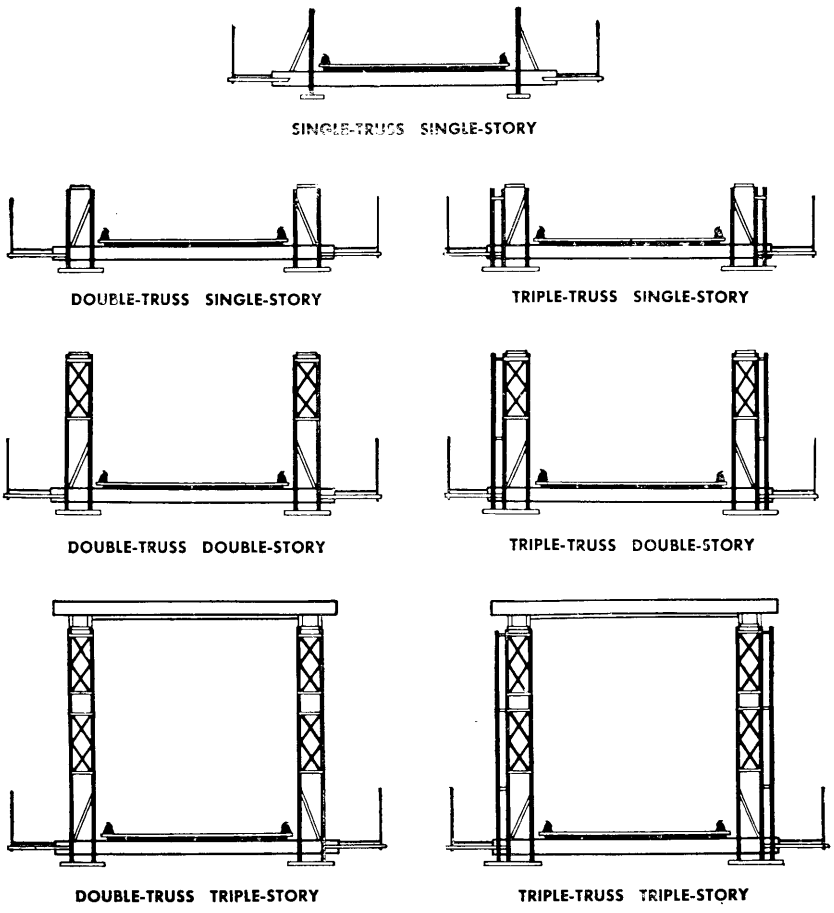


Figure 4. Types of truss construction.

13. Deck

The clear roadway between guardrails, called ribands, is 12 feet 6 inches wide. The transom supporting the roadway is normally set on the bottom chords of the bottom story. Ramps are used at each end of the bridge. The slope of the ramp must not exceed 10 to 1 for loads up to and including 50 tons, and 20 to 1 for loads over 50 tons. Two footwalks, 2 feet 6 inches wide, can be carried on the transoms outside of the main trusses on each side of the bridge.

14. Bearings

End posts pinned to the end of each truss sit on cylindrical bearings, which rest on a steel base plate. On soft soil, timber grillage is used

under the base plates to distribute the load. The bridge can be built between banks at different elevations, but the slope should not exceed 30 to 1.

15. Weight

Table 1 gives the weights of 10-foot bridge bays.

Table 1. Weight of M2 Panel Bridge in Tons Per Bay

Type of construction[1]	Weight (tons)
Bridge bays	
SS	2.93
DS	3.58
TS	4.18
DD	4.83
TD	6.05
DT[2]	6.63
TT[2]	8.46
Launching-nose bays	
SS	1.00
DS	1.64
DD	2.90
Decking	
Chess and steel ribands	0.66
Stringers only	0.79
Wear treads (four 3″ x 12″ planks on each side)	0.35
Miscellaneous	
Footwalks	0.17
Overhead bracing (supports, transoms, sway bracing, and chord bolts)	0.54

[1] Footwalks included. Wear treads not included.
[2] Overhead bracing included.

CHAPTER 4

CAPACITY AND CLEARANCE

Section I. BRIDGE CAPACITY

16. Scope

a. CAPACITY DATA. Section 1 of this chapter gives capacity data on simple spans of the M2 fixed panel bridge. These data are based on strain-gage tests, ultimate capacity tests, and computation by the Engineer Research and Development Laboratories and supersede all previous data.

(1) For capacity data on other types of panel bridges, see the following chapters in part three of this manual:

Two-lane through type bridges (ch. 20).
Deck type bridges (ch. 21).
Railway bridges (ch. 22).
Reinforced bridges (ch. 23).
Bridges on piers (ch. 24).
Bridges on barges (ch. 26).

Capacity data on the M1 fixed bridge and the British Bailey bridges are given in appendixes II and III, respectively.

(2) Capacity data in this section are for bridges built with parts manufactured in the United States.

b. HORIZONTAL AND VERTICAL CLEARANCE. Section 2 of this chapter gives the critical horizontal and vertical clearance with respect to passage of traffic over the M2 panel bridge.

17. Construction

a. SPANS AND TYPES OF CONSTRUCTION CONSIDERED. (1) *Spans.* The spans considered range from 30 to 210 feet. However, the long spans become increasingly uneconomical because of excessive dead weight and reduced capacity. For efficient construction, the time required to assemble one span and prepare it for launching should be as nearly equal as possible to the time required to build and place one pier. Generally, intermediate piers should be used to avoid construction of US class 50 spans longer than 150 feet or US class 75 spans longer than 120 feet.

(2) *Trusses.* Only through type bridges with single, double, and triple trusses are considered. Special quadruple trusses used in railway bridges are not included.

b. ASSUMED CONSTRUCTION. The following construction details were assumed in determining capacity data:

(1) *Transoms.* Single transoms placed every 5 feet are adequate to support all present US vehicles on M2 panel bridges.

(2) *Supports under end transoms.* Cribbing and wedges are used under middle of end transoms in bridges of US class 39 or more.

(3) *Intermediate ramp supports.* Cribbing and wedges are placed under midspan of ramps on bridges of US class 45 or more.

(4) *Overhead bracing supports.* Overhead bracing is used on triple-story bridges having all three stories above the floor system (ch. 13).

(5) *Footwalks.* Footwalks are omitted.

(6) *Floor protection.* Eight 3- by 12-inch wear treads are added to flooring to prevent excessive wear of chess by tracked vehicles.

18. Vehicles

Typical and critical military wheeled, tracked, and combination vehicles are considered in the capacity bar charts (tables 2, 3, and 4). Vehicles not listed in the bar charts can be rated safe, caution, or unsafe by comparing their weight-class with the safe and caution capacities at the head of each column in the charts. To determine the weight-class of vehicles, see paragraph 239, FM 5–10.

19. Capacity Bar Charts (tables 2, 3, and 4)

a. PURPOSE. (1) *Safe bridge capacities.* Column headings of the capacity bar charts give *safe* capacities for all spans and types of construction of the M2 panel bridge. Safe capacities are also given in table 5. They are used in traffic control and staff planning.

(*a*) *Traffic control.* A bridge is posted with its safe capacity. When a vehicle comes to the bridge, the weight-class marked on the vehicle is compared with the posted capacity of the bridge. If the weight-class of the vehicle equals or is less than the posted capacity of the bridge, the vehicle can cross safely. If the vehicle weight-class exceeds the posted capacity by not more than 25 percent, the vehicle can cross with caution (par. 240*a*(1), FM 5–10). This procedure is simple and *in most cases sufficiently precise.* No reference to a bar chart or table is required except to post the bridge.

(*b*) *Staff planning.* The bar charts, or table 6, can be used to determine the type of bridge needed to cross a given class of vehicle over a given span. (See *d* below.)

(2) *Caution bridge capacities.* The bar charts, or table 5, also give *caution* capacities for all spans and types of construction. Normally, these capacities are not posted on the bridge. However, instead of using the 25 percent overload rule, they can be posted and used in the same manner as safe capacities when maximum bridge economy is desired.

(3) *Vehicle ratings.* The bar charts give safe, caution, risk, and unsafe ratings of typical and critical military vehicles in relation to all spans and types of construction of the panel bridge. This information is used in *unusual cases* where it is necessary to pass critical vehicles normally barred from the bridge.

(*a*) *Traffic control.* Bar charts are consulted when it is desired to cross a vehicle with a weight-class exceeding the safe (posted) or caution capacity of the bridge. *In this way, maximum use can be made of the bridge.* (See examples in *c* below.) Vehicles with *risk* rating cross *only when absolutely necessary. Repeated use of bridges for risk loads may result in their collapse.* An *engineer officer is present* to insure enforcement of traffic regulations. He inspects the bridge after *each* risk crossing for signs of failure and replaces damaged parts. *The bridge will not be reused until this inspection has been made.*

(*b*) *Staff planning.* Bar charts determine whether bridges of a given class (posted capacity) and span will pass *critical* vehicles that are normally barred because their weight-class exceeds the class of the bridge. Vehicle ratings on the bar charts can also be used to select the most economical bridge-class for a road net that is to be used for specified *critical* vehicles.

b. MEANING OF SAFE, CAUTION, AND RISK. (1) *Criteria for individual ratings.* Vehicle ratings in the bar charts satisfy the following criteria:

		Safe rating	Caution rating	Risk rating
Traffic restrictions	Position ...	Any place on deck.	On center line of deck.	On center line of deck.
	Max speed .	25 mph.	5 mph.	3 mph with guide.
	Operation ..	No sudden stopping or accelerating.	No stopping, braking, or gear shifting.	No stopping, braking, or gear shifting.
	Min spacing	Vehicles spaced at least 30 yards tail to head.	Vehicles spaced at least 50 yards tail to head.	One vehicle on bridge at a time.

(2) *Criteria for bridge ratings.* Posted (safe) and caution capacities at head of columns in the bar charts are derived from vehicle ratings.

c. USE OF CHARTS TO CROSS CRITICAL VEHICLES. The following examples show how the bar charts are used to cross *critical* vehicles that are normally barred because their weight-class exceeds the posted capacity of the bridge. The examples have been selected to illustrate various conditions that can arise and *must not be regarded as typical.*

(1) *Wheeled vehicle.* A 10-ton truck, heavy wrecker, M1 (weight-class 20) comes to a 150-foot TS panel bridge (bridge-class 13). The vehicle cannot pass as a safe load because its weight-class exceeds the posted class (safe capacity) of the bridge. It cannot cross with caution by the 25-percent overload rule because its weight-class exceeds the

class of the bridge by more than 25 percent. Furthermore, the bar chart for wheeled vehicles (table 2) shows the bridge has a caution capacity of only 19 tons. However, the rating of the vehicle for this bridge is in the shaded area of the chart, and therefore, the vehicle can cross with *caution*.

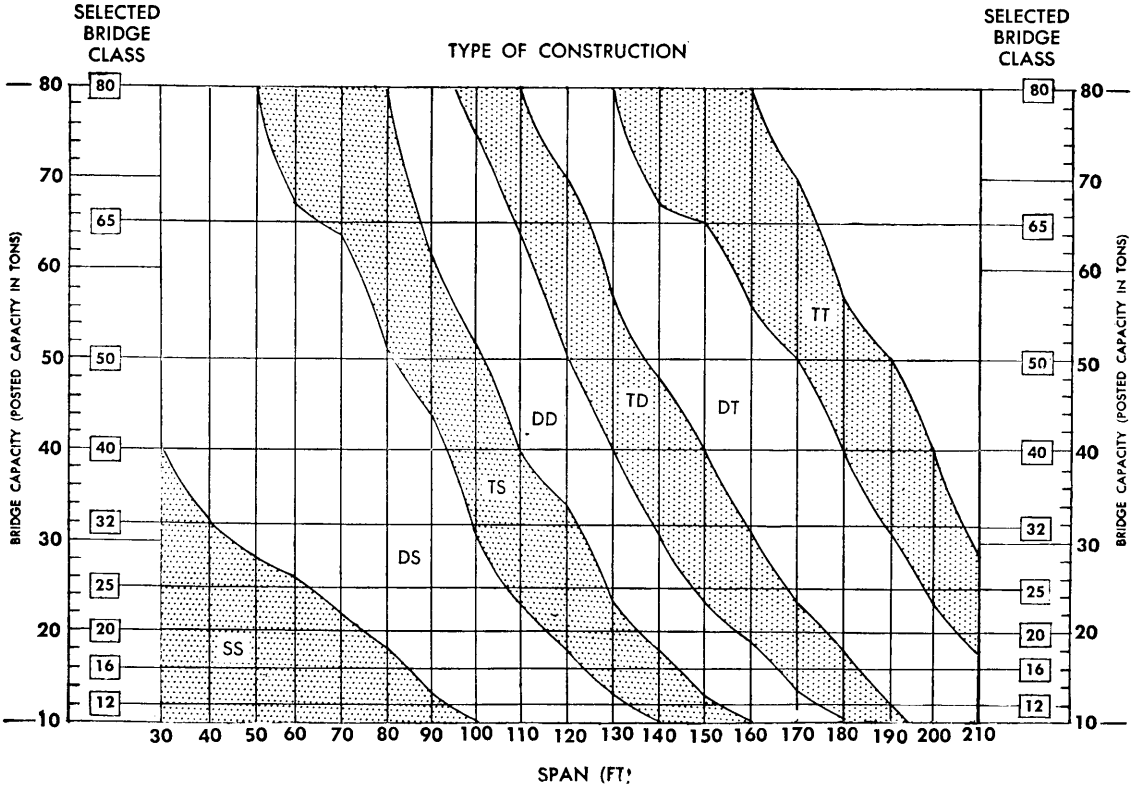
(2) *Tracked vehicle.* An M26 medium tank (weight-class 46) comes to 90-foot DS bridge (bridge-class 44). Although it can pass with caution as less than a 25 percent overload and its weight-class is less than the caution capacity of the bridge (55 tons), the rating of the vehicle on the bar chart for tracked vehicles (table 3) is in the unshaded area, indicating it can cross as a *safe* load.

(3) *Combination vehicle.* A 7½-ton truck with a 20-ton trailer (weight-class of combination 39) comes to a 50-foot SS bridge (bridge-class 28; caution capacity 38). The vehicle weight-class exceeds the posted class (safe capacity) of the bridge. It cannot cross with caution by the 25 percent overload rule because its weight-class exceeds the class of the bridge by more than 25 percent. Furthermore, the bar chart for combination vehicles (table 4) shows the bridge has a caution capacity of only 38 tons. However, the rating of the vehicle for this bridge is in the unshaded area of the chart, and therefore, the vehicle can cross as a *safe* load.

Table 5. Safe and Caution Capacities of M2 Panel Bridge

Span (ft)	Construction													
	SS		DS		TS		DD		TD		DT		TT	
	Capacity (tons)													
	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution
30	40	55												
40	32	45												
50	28	38	80	100										
60	26	35	67	84										
70	22	31	64	80										
80	18	23	51	64	80	100								
90	13	19	44	55	62	78								
100	10	13	31	40	52	65	75	94						
110			23	34	40	50	64	80	80	100				
120			18	23	34	43	50	63	70	88				
130			13	19	23	32	40	51	57	75	80	100		
140			10	13	18	23	31	44	48	61	67	87		
150					13	19	23	32	40	50	65	81		
160					10	13	19	29	31	43	56	70	80	100
170							13	19	23	31	50	63	70	88
180							10	13	18	23	40	50	57	75
190									12	16	31	44	50	64
200											23	31	40	50
210											18	23	29	36

Table 6. Truss Construction for Various Spans and Bridge Classes of M2 Panel Bridge



d. USE OF THE BAR CHARTS TO SELECT TYPE OF BRIDGE. When the class and span of a planned bridge are known, table 6, based on the bar charts, can be used to find the most economical type of construction. This table gives the proper truss construction for various spans and bridge-classes. The table also has typical selected bridge-classes from 12 to 80 to aid choice of truss construction required. Selected bridge-classes to be used are determined by theater commander.

Section II. CLEARANCE

20. Horizontal Clearance

The M2 panel bridge is 150 inches wide between steel ribands and 171 inches between trusses (fig. 5). Since steel ribands are only 10½ inches inside trusses, the 3- by 12-inch timber guards shown in figure 5 are used to protect trusses against vehicles with overhanging bodies. Figure 6 shows the clearance of the M26 tank on a standard bridge.

21. Vertical Clearance

Figure 7 shows the critical vertical clearances for the standard bridge. In some cases a variation in the type of normal construction may be required in order to provide adequate clearance for vehicles with overhanging bodies or loads. The vertical clearance in triple-story bridges is of prime importance when loaded tank transporters pass over them. This is especially true when expedient overhead bracing is used. In cases where vehicles limit the vertical clearance to single-story construction at the deck level, underslung stories may be used to provide the required bridge classification.

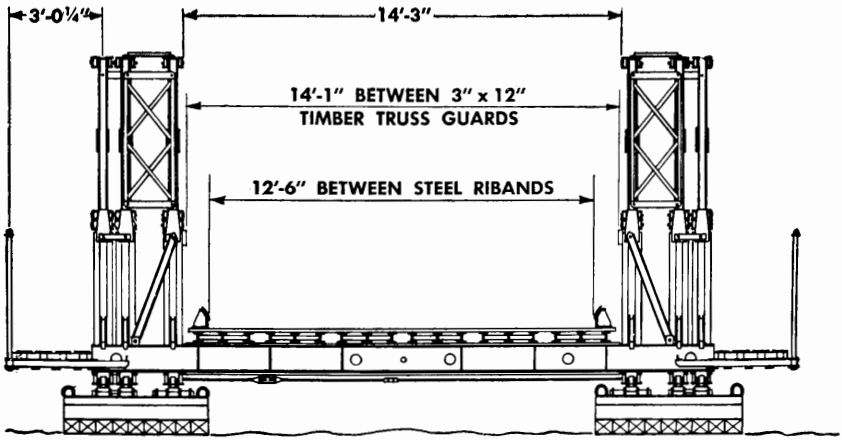


Figure 5. Triple-double bridge showing critical horizontal clearance.

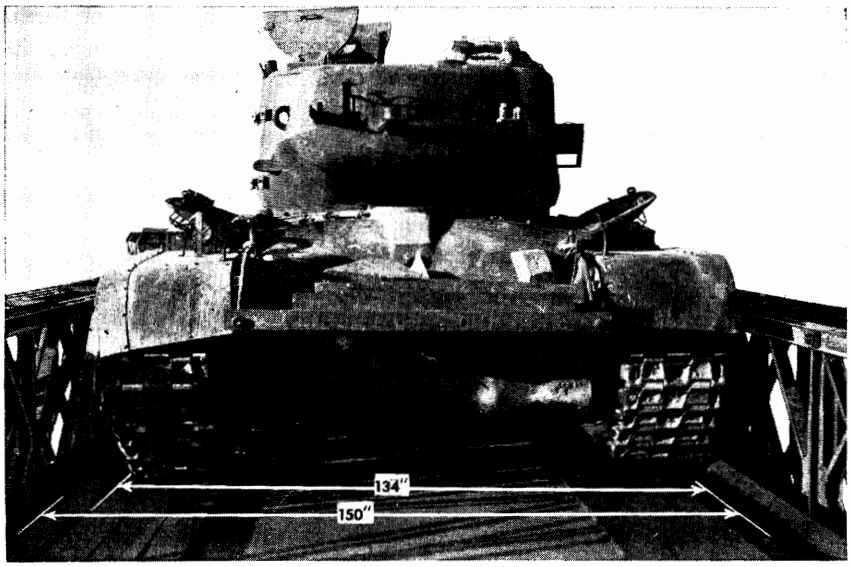


Figure 6. M26 tank on M2 bridge.

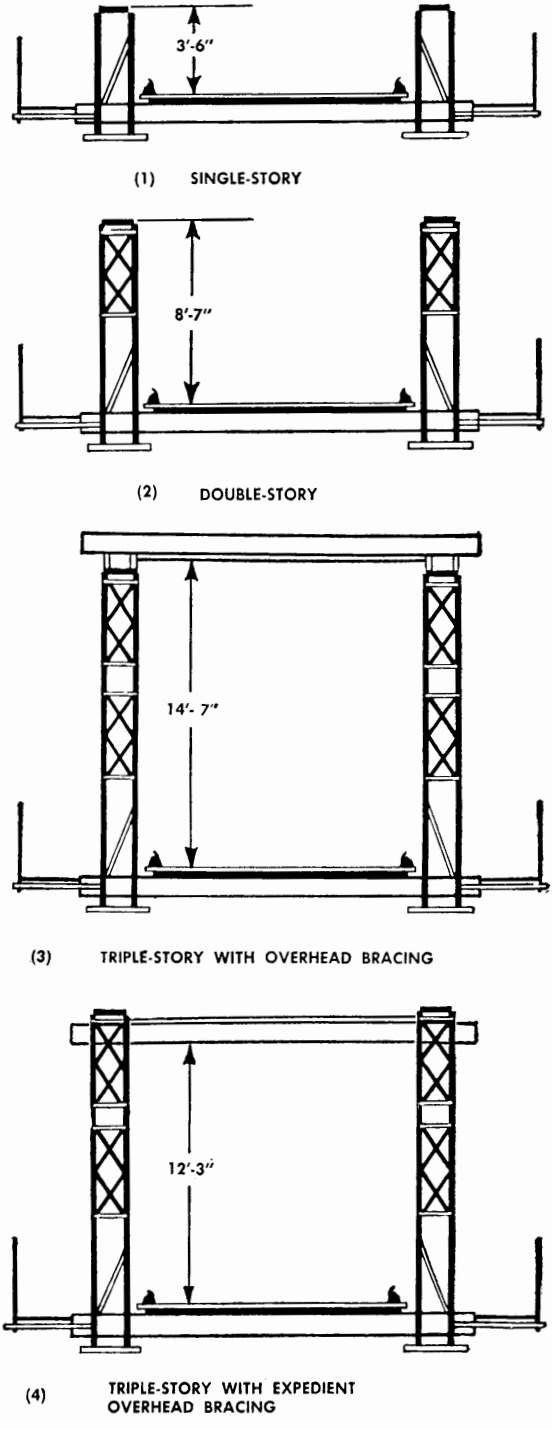


Figure 7. Double-truss bridges showing critical vertical clearance.

CHAPTER 5

DESCRIPTION OF EQUIPMENT

Section I. BRIDGE PARTS

22. General

The bridge equipment and erection equipment supplied in the panel bridge set are listed in table 10 and illustrated in figures 8 and 9. Figures 10, 11, and 12 show the location of the parts in the bridge.

23. Panel

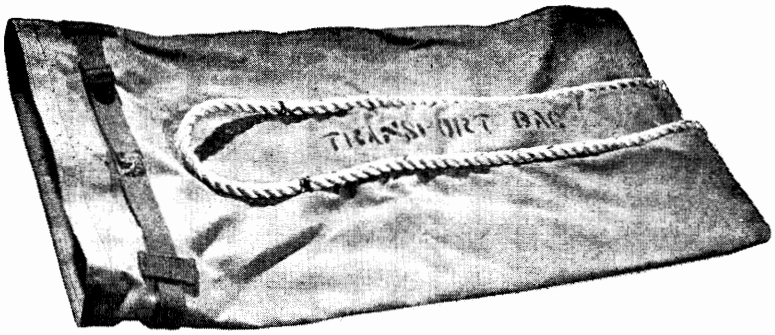
a. The panel is the basic member of the bridge. It is a welded high-tensile steel truss section 10 feet long, 5 feet 1 inch high, and 6½ inches wide. It weighs 577 pounds and can be carried by six men using carrying bars.

b. The horizontal members of the panel are called chords. Transoms are clamped to four seatings on top of the bottom chord next to the panel verticals. Table 7 lists the holes in the panel chords and verticals.

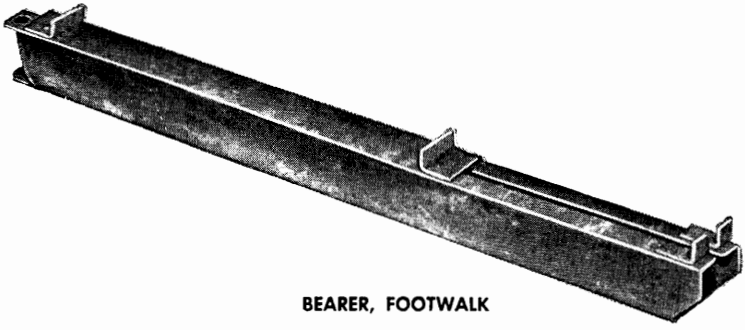
Table 7. Holes in Panel Chords and Verticals

Position of hole (see fig. 10)	Type of bolt used in hole	Use of hole
Near each end of bottom chord.	Sway brace pin.....	Fasten ends of sway braces.
Top and bottom chords.	Bracing bolt	Fasten bracing frames between two inner trusses.
Top and bottom chords.	Chord bolt	Fasten chords of multi-story bridges.
End verticals	Bracing bolt	Fasten rakers.
		Fasten bracing frames between two inner trusses.
		Fasten tie plates between second and third trusses.

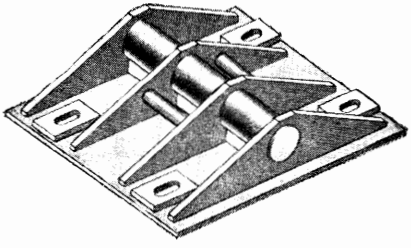
c. Both chords have male lugs at one end and female lugs at the other. Panels are joined end to end by engaging these lugs and placing panel pins through the holes in the lugs.



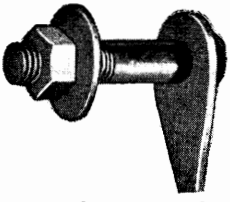
BAG, TRANSPORT



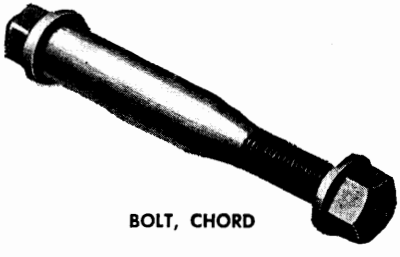
BEARER, FOOTWALK



BEARING, 4 5/16" HIGH

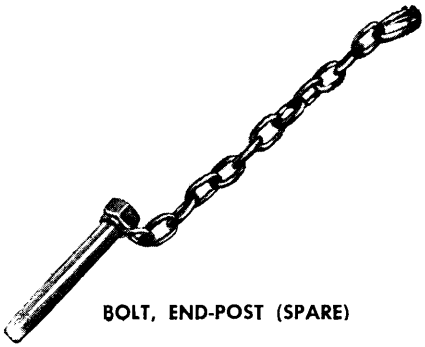


BOLT, BRACING

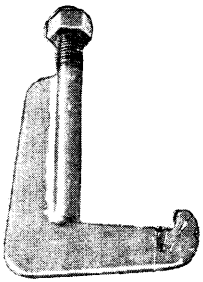


BOLT, CHORD

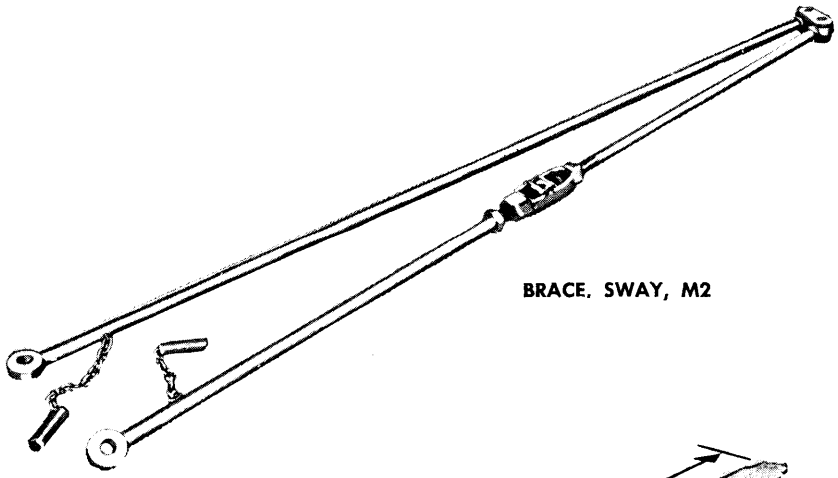
Figure 8. Panel bridge equipment—bridge parts.



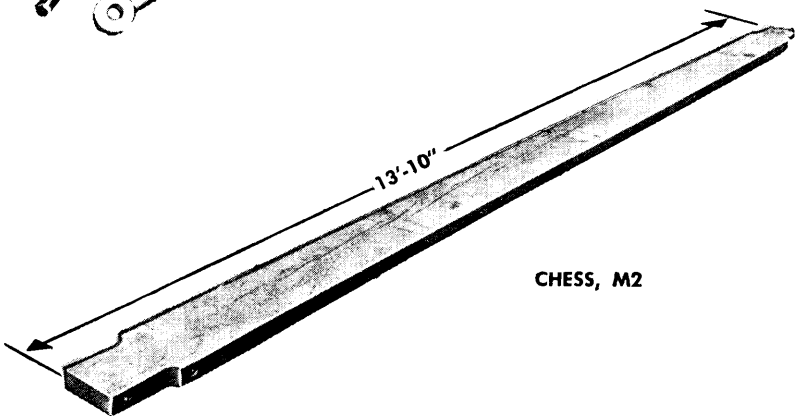
BOLT, END-POST (SPARE)



BOLT, RIBAND, GUARDRAIL

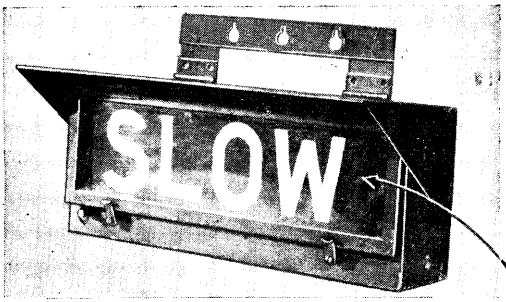


BRACE, SWAY, M2



CHESS, M2

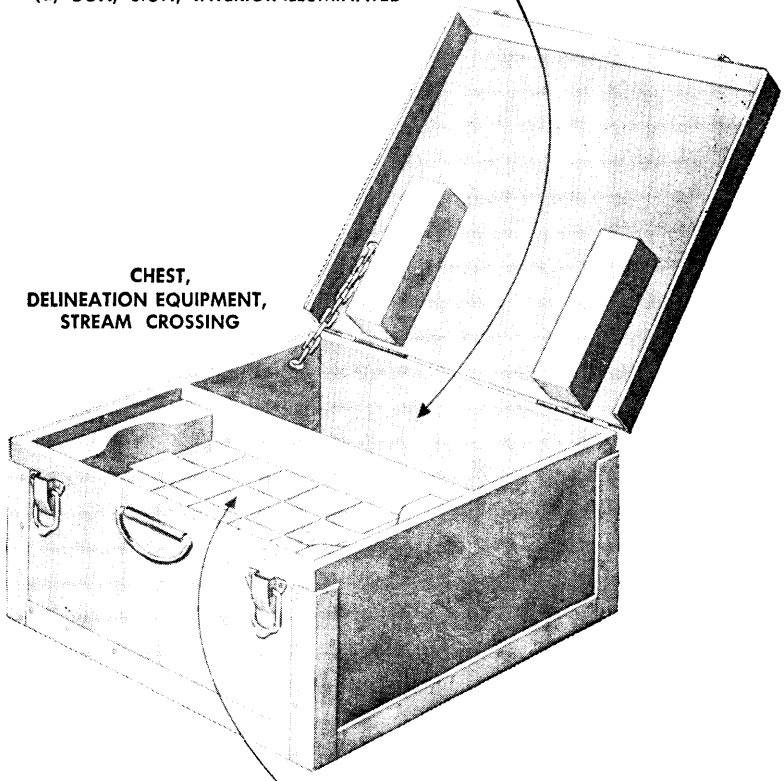
Figure 8—Continued.



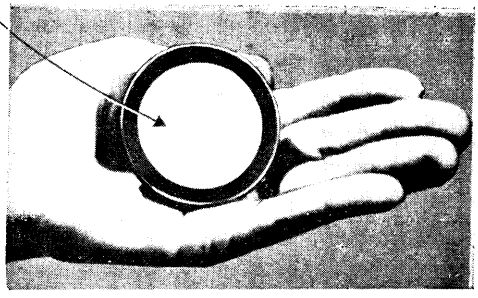
(a) BOX, SIGN, INTERIOR-ILLUMINATED

2 INTERIOR ILLUMINATED SIGN BOXES

CHEST, DELINEATION EQUIPMENT, STREAM CROSSING

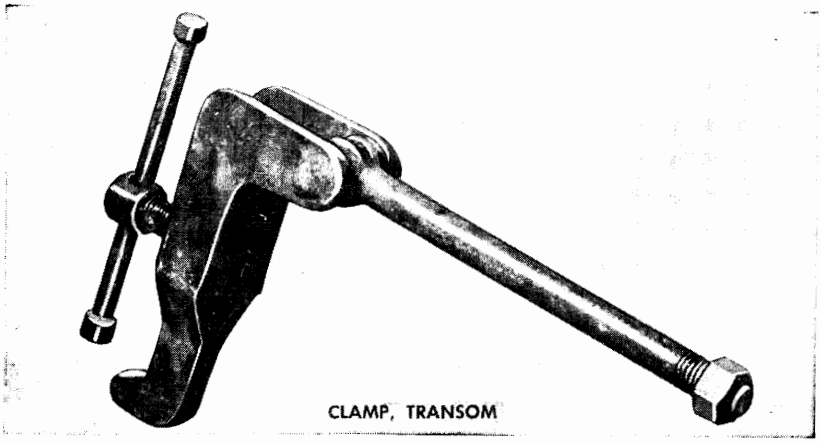


100 LUMINOUS MARKERS

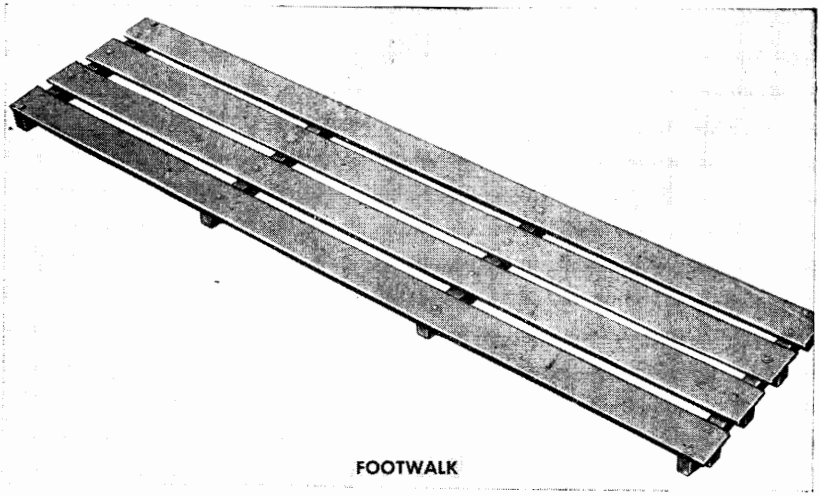


(b) MARKER, LUMINOUS, RADIOACTIVE

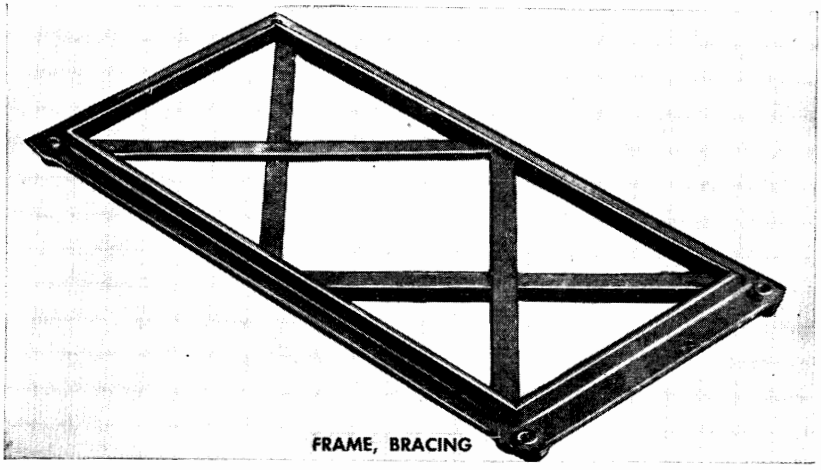
Figure 8—Continued.



CLAMP, TRANSOM

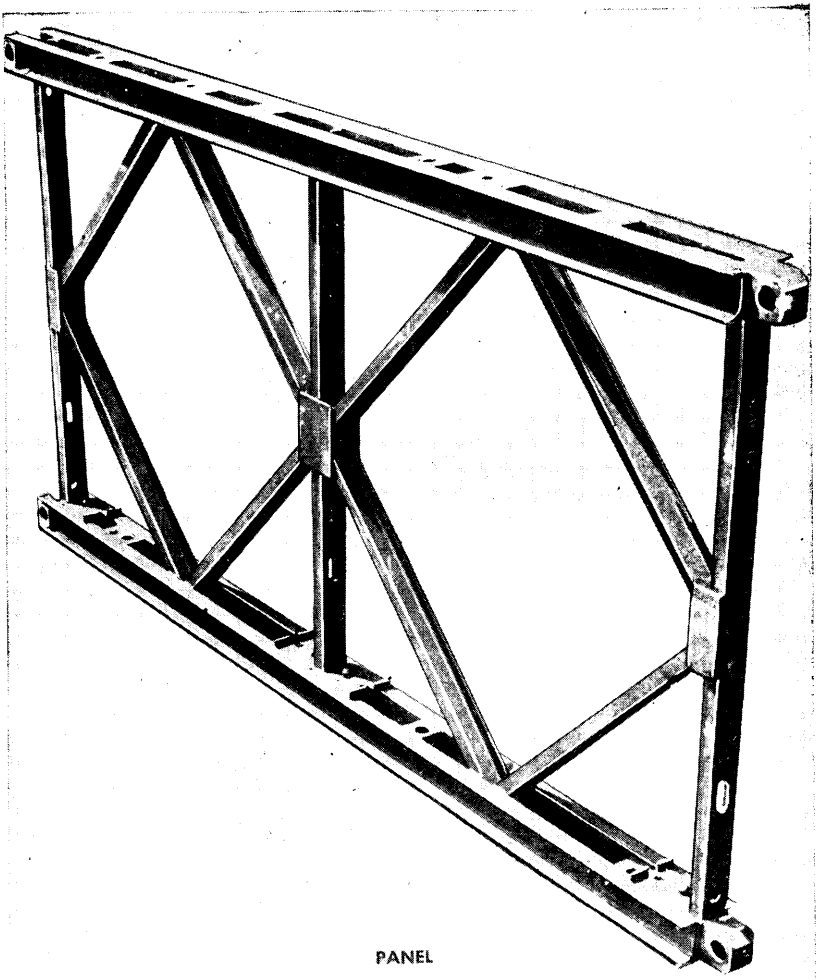


FOOTWALK

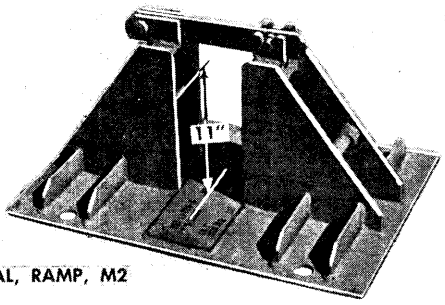


FRAME, BRACING

Figure 8—Continued.

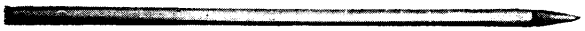


PANEL

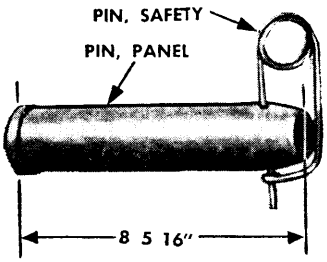


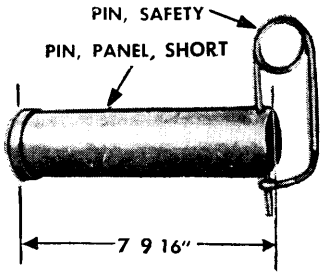
PEDESTAL, RAMP, M2

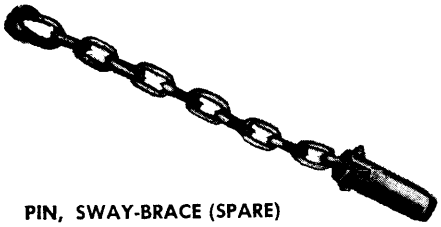
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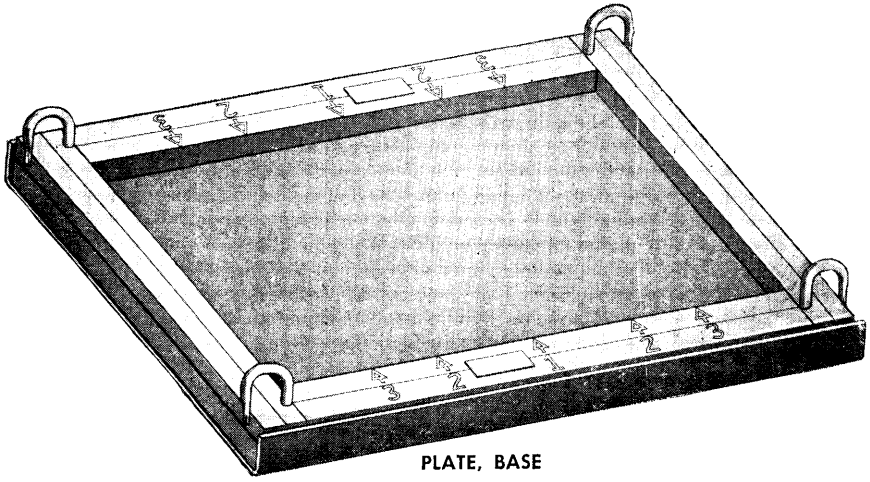
PICKET, STEEL



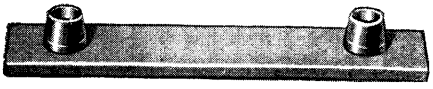




PIN, SWAY-BRACE (SPARE)



PLATE, BASE



PLATE, TIE

Figure 8—Continued.

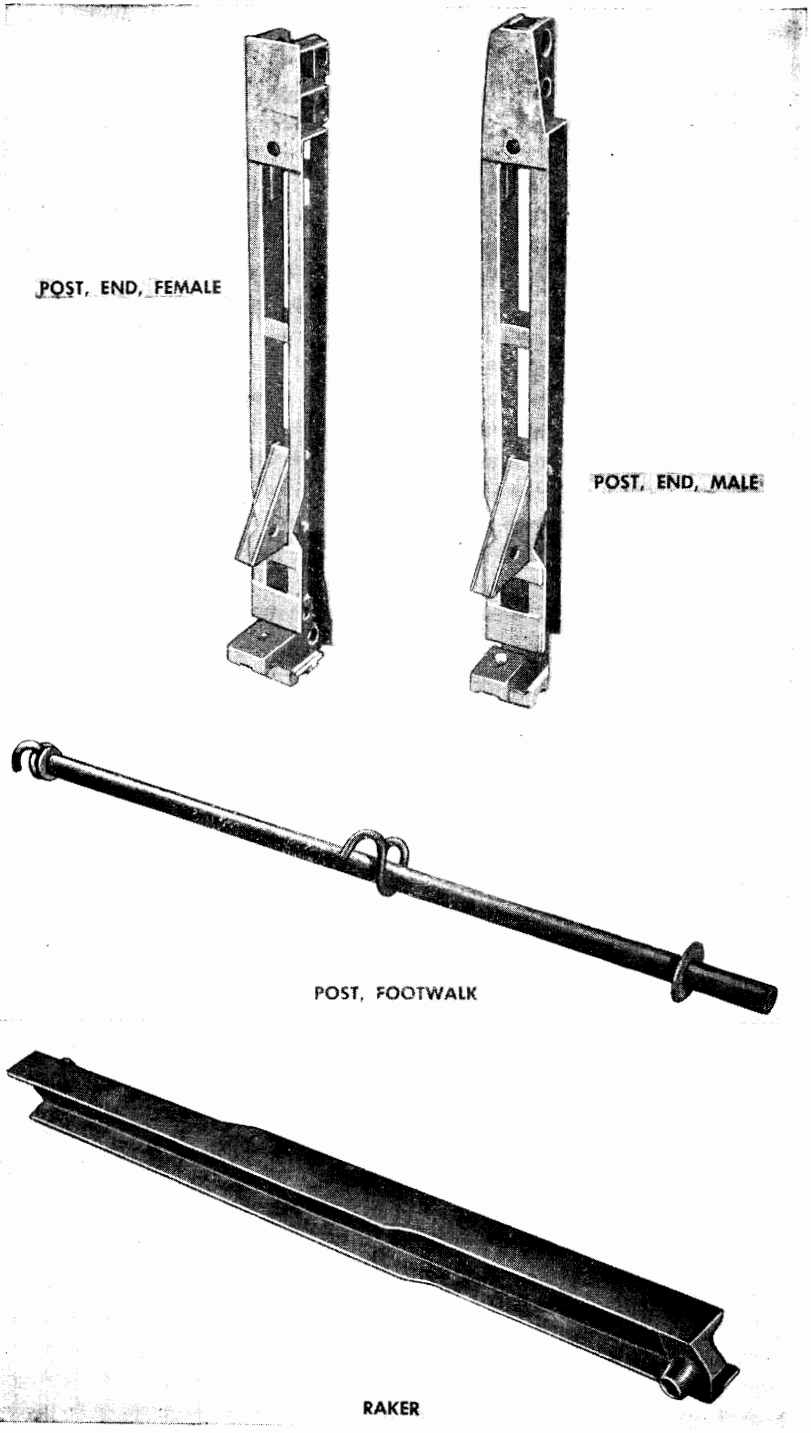


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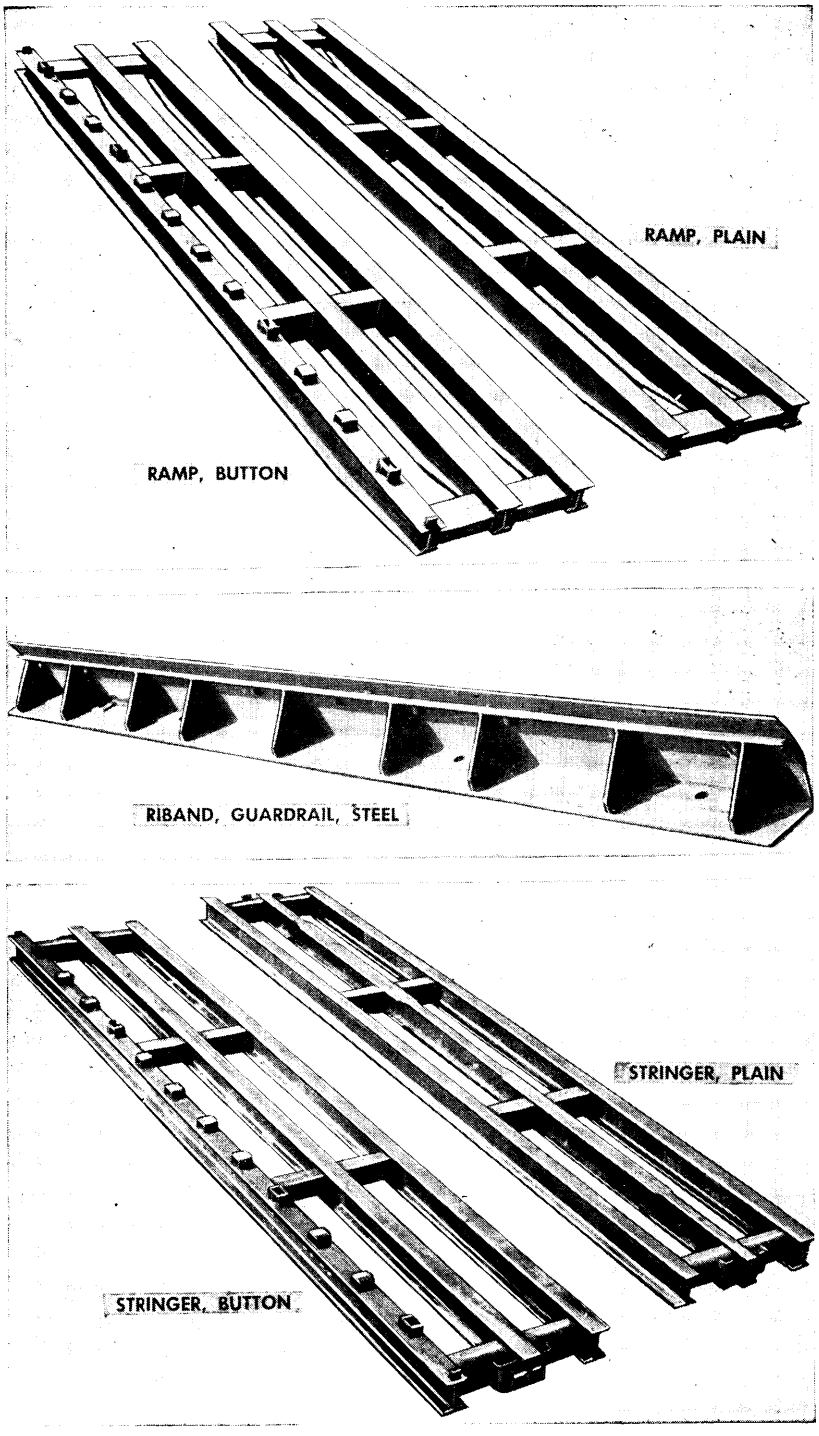
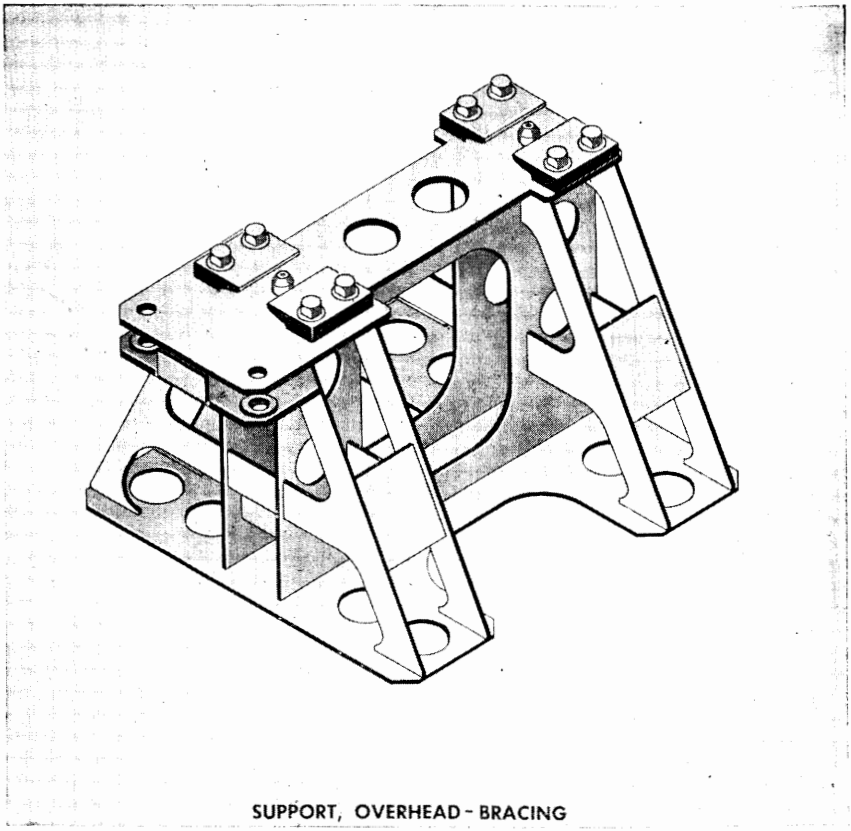


Figure 8—Continued.



SUPPORT, OVERHEAD - BRACING

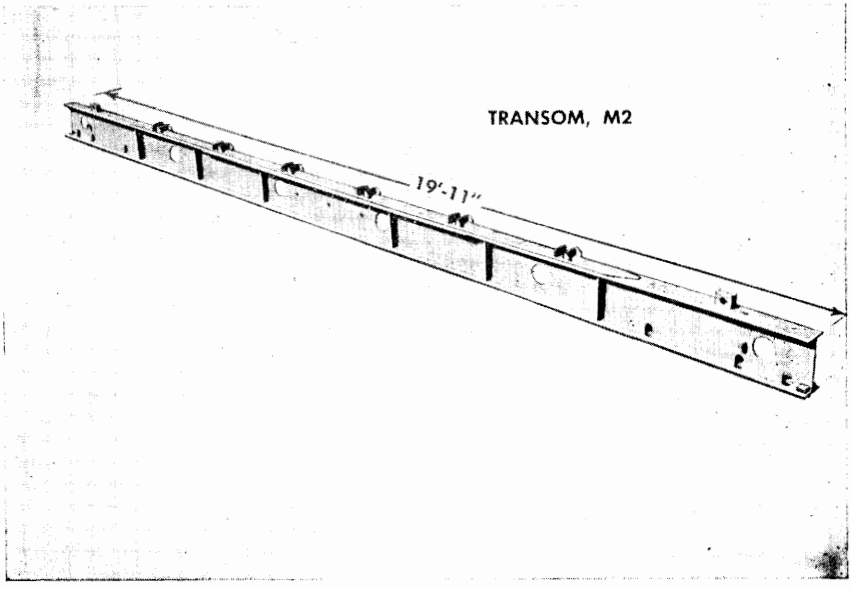


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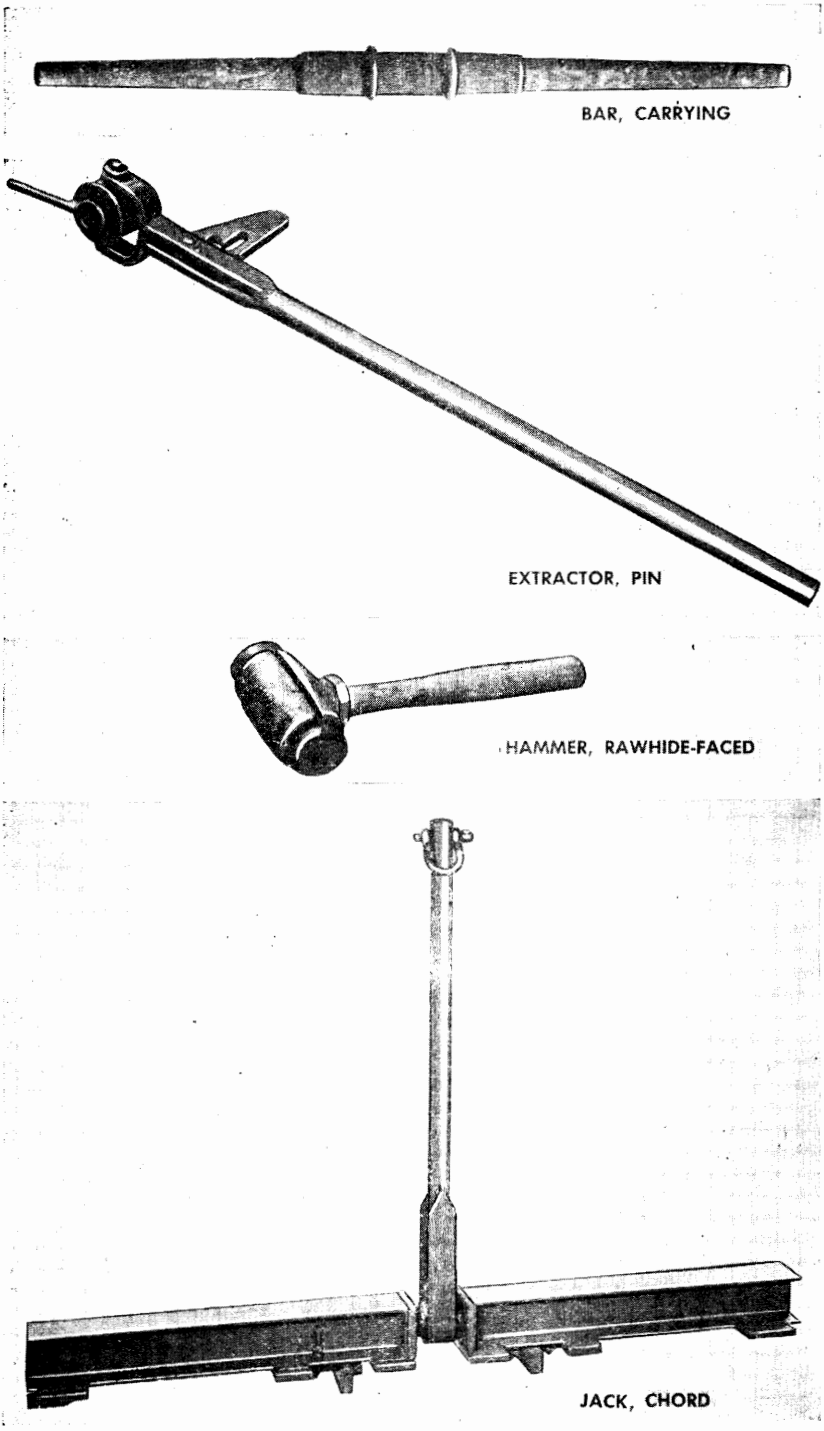
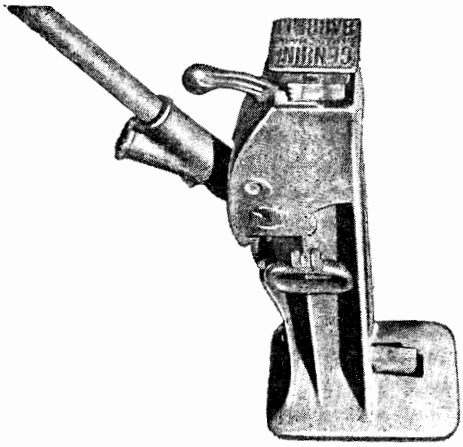
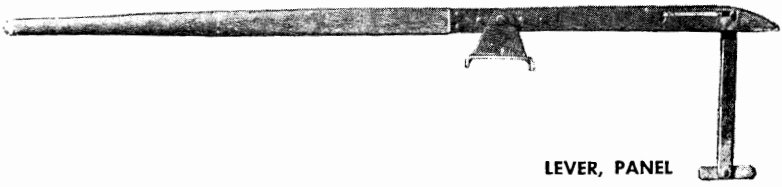


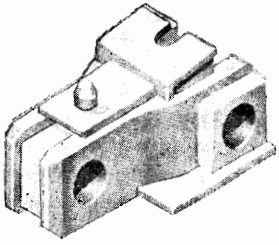
Figure 9.—Panel bridge erection equipment.



JACK, RATCHET-LEVER,
15-TON



LEVER, PANEL



LINK, LAUNCHING-NOSE, MKII

ROLLER, PLAIN

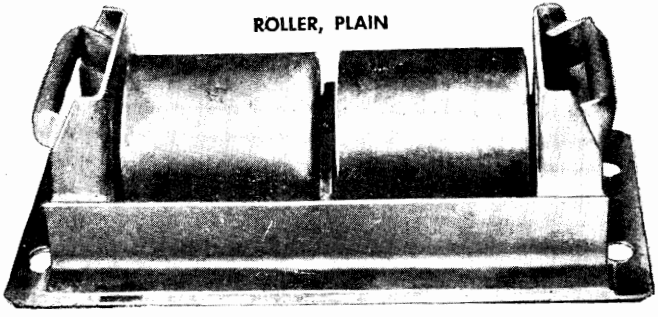
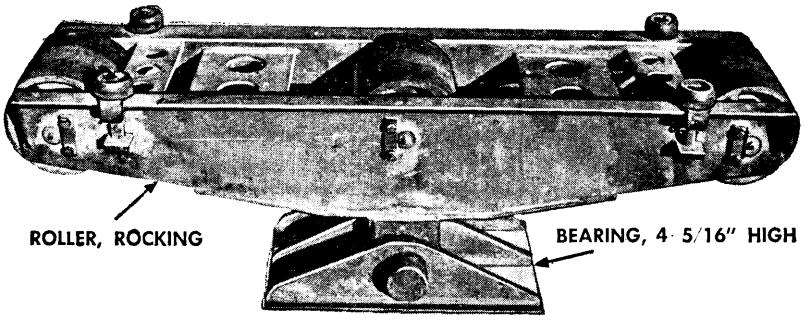
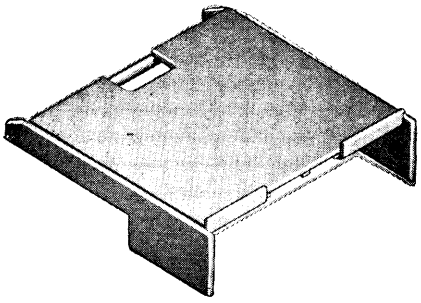


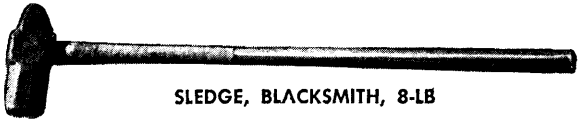
Figure 9—Continued.



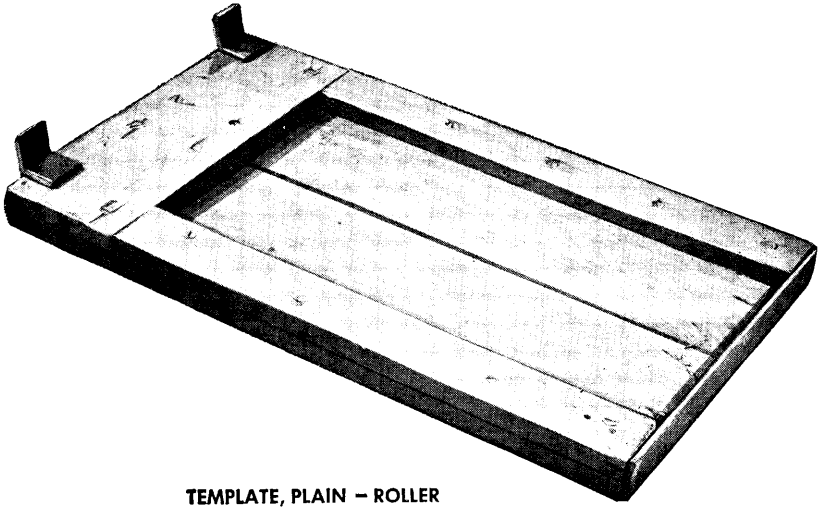
ROLLER, ROCKING



SHOE, JACK, 4 3/16" HIGH

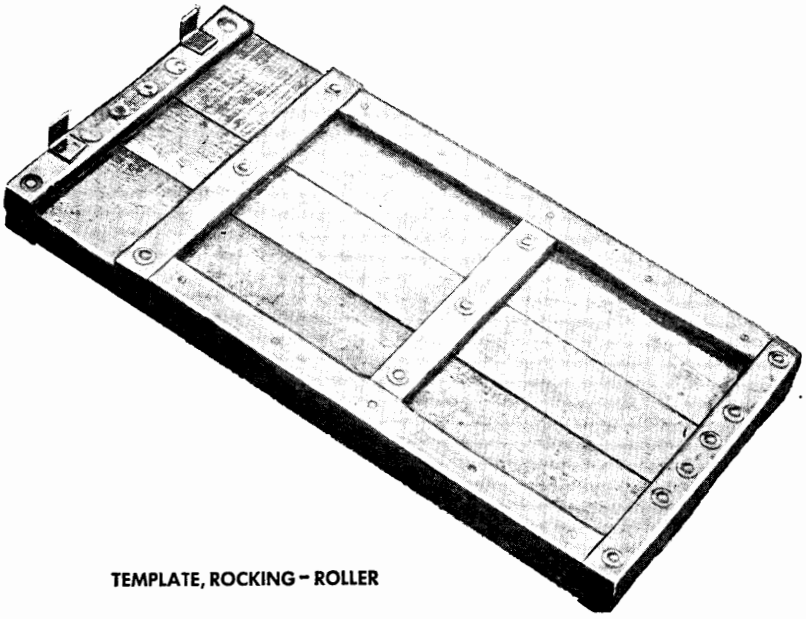


SLEDGE, BLACKSMITH, 8-LB

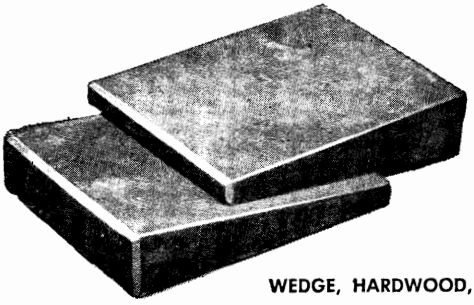


TEMPLATE, PLAIN – ROLLER

Figure 9—Continued.



TEMPLATE, ROCKING – ROLLER



WEDGE, HARDWOOD, (PR)

WRENCHES

(1) WRENCH, SOCKET, OFFSET 90°, 1⅛", FOR ¾" BOLTS

(2) WRENCH, STRUCTURAL, OFFSET, 1⅛", FOR ¾" BOLTS

(3) WRENCH, STRUCTURAL, OFFSET, 1½" FOR 1" BOLTS

(4) WRENCH, STRUCTURAL, OFFSET, 1⅞" FOR 1¼" BOLTS

(5) WRENCH, RATCHET, WITH (a) 1⅞" AND (b) 1⅛" SOCKETS, FOR 1¼" AND ¾" BOLTS

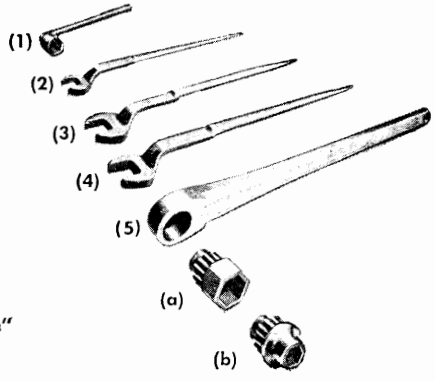


Figure 9—Continued.

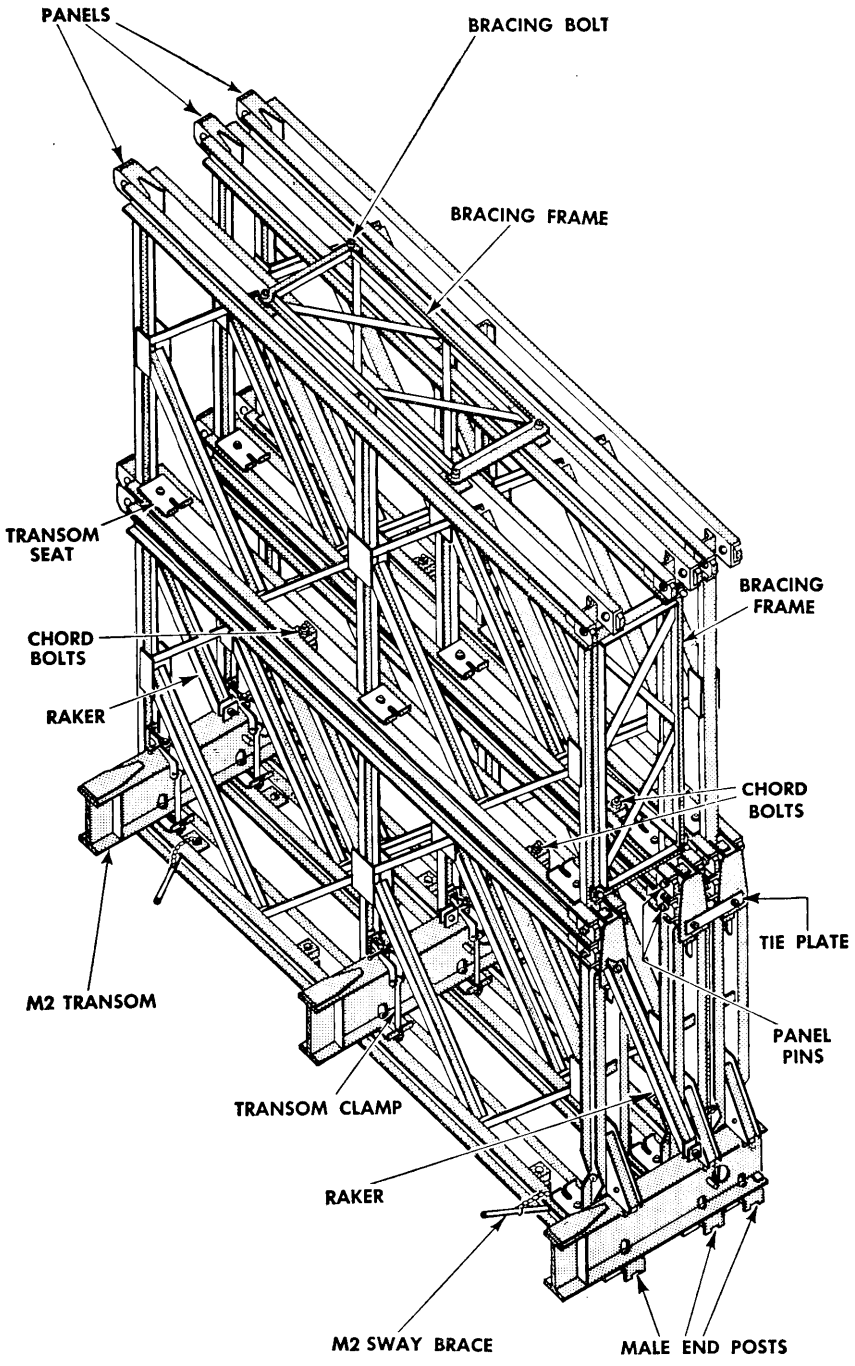


Figure 16. Location of bridge parts in trusses of triple-double bridge.

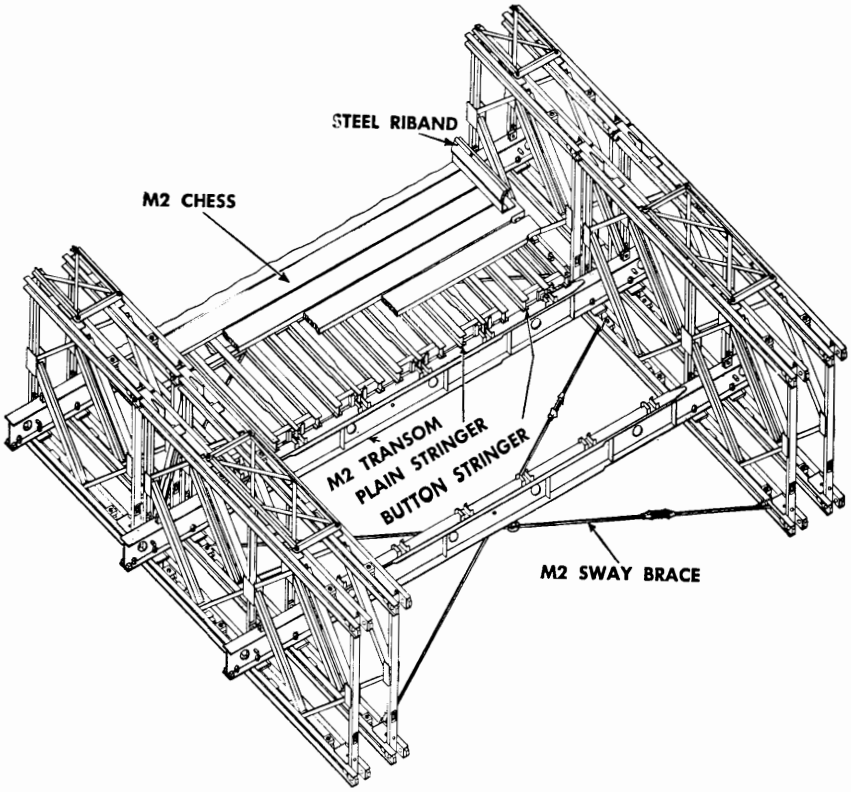


Figure 11. Location of bridge parts in decking of double-single bridge.

24. Panel Pin

The panel pin is 8 inches long, 1⅞ inches in diameter, and weighs 6 pounds. It has a tapered end with a small hole for a safety pin. A groove is cut across the head of the panel pin parallel to the safety-pin hole. Panel pins should be inserted with the groove horizontal; otherwise, the flanges of the panel chord channels make it difficult to insert the safety pin.

25. Short Panel Pin

The short panel pin is ¾ inches shorter than the normal panel pin and weighs 5.8 pounds. It is used to pin the end posts of the middle and outer trusses in a triple-truss bridge.

26. Transom

a. The transom supports the floor system of the bridge. It is a 10-inch I-beam, 19 feet 11 inches long, with a 4½-inch flange and a 5/16-inch

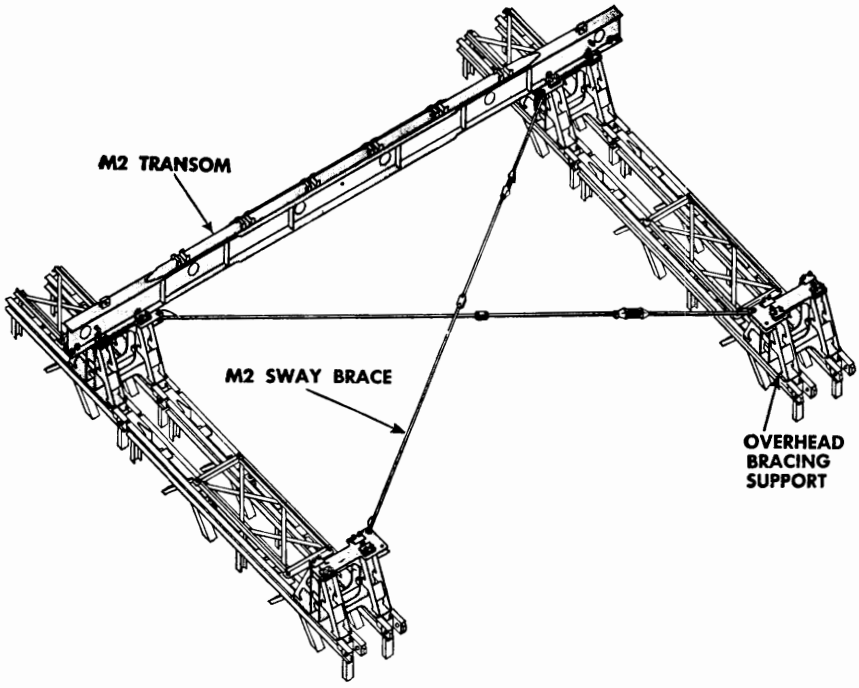


Figure 12. Location of bridge parts in overhead bracing of double-triple bridge.

cover plate on each flange. It weighs 618 pounds and is carried by eight men using carrying bars inserted through holes in the web.

b. The under side of the transom has six holes into which the panel dowels fit. The upper side on the transom has six lugs which position the stringers, and an additional lug near each end to which the raker, or side strut, is bolted. Lugs for the footwalk bearer are near each end on the web and flange of the I-beam.

c. The transoms rest on the lower chords of the panels and are held in place by transom clamps. Transoms are spaced 5 feet apart, one at the middle and one at one end of each panel (fig. 10). The bridge must never be jacked up under transoms because the transom clamps will fail.

27. Transom Clamp

The transom clamp is a hinged screw type clamp, 13½ inches high and 8 inches across the top. It weighs 7 pounds. It clamps the transom to the vertical and bottom chord of the panel. It is tightened by a vise-handled screw.

28. Raker

The raker is a 3-inch I-beam with a 2⅜-inch flange. It is 3 feet 8 inches long and weighs 22 pounds. A raker connects the end of the transom to the top of the panels of the inner truss and prevents the panels from overturning. At each end of the raker is a hollow dowel for the bracing bolts; it fits through a hole in the panel and a hole in the transom.

29. Bracing Frame

a. A bracing frame is a rectangular frame, 4 feet 3 inches by 1 foot 8 inches, with a hollow conical dowel in each corner. It weighs 44 pounds.

b. The bracing frame is used to brace the inner two trusses on each side of double- and triple-truss bridge. Bracing bolts attach the bracing frames horizontally to the top chords of the bridge and vertically on one end of each panel in the second and third stories.

30. Sway Brace

The sway brace is a 1⅛-inch steel rod, hinged at the center, and adjusted by a turnbuckle. It weighs 68 pounds. At each end is an eye, through which a pin on a chain is inserted to secure it to the panel. The sway brace is given the proper tension by inserting the tail of an erection wrench in the turnbuckle and screwing up tight. The lock nut is then screwed up against the turnbuckle. Two sway braces are required in lower chord of each bay of bridge and all except first bay of launching nose, and in each bay of overhead bracing.

31. Tie Plate

A tie plate is a piece of flat steel 2½ by ⅜ by 12 inches weighing 3½ pounds. It has a hollow conical dowel at each end. The tie plate is used only in triple-truss bridges; it secures the second truss to the third truss, using the unoccupied raker holes in the panels at each joint and at the ends of the bridge.

32. Bracing Bolt

a. A bracing bolt is ¾ inch in diameter, 3½ inches long, and weighs about 1 pound. A special lug on its head prevents rotation when the bolt is tightened. A 1⅛-inch wrench is used to tighten it.

b. It is used to (1) attach rakers to transoms and panels, (2) attach bracing frames to panels, and (3) attach tie plates to panels. It is inserted into the hollow dowels of the braces to draw parts into proper alinement.

33. Chord Bolt

a. A chord bolt is 1¾ inches in diameter, 10½ inches long, and weighs 7½ pounds. It is tapered through half its length to assist in drawing the panels into alinement. A 1⅞-inch wrench is used to tighten it.

b. Chord bolts join the panels one above the other to form double- and triple-story bridges. Two bolts per panel pass upward through holes in the chords of the panels and are tightened with nuts on the lower chord of the upper story. They are also used to fasten overhead bracing supports to the top panel chord.

34. Stringers

a. Stringers carry the roadway of the bridge. Each stringer consists of three 4-inch steel I-beams, 10 feet long, joined by welded braces. There are two types of stringers: plain stringers weighing 260 pounds, and button stringers weighing 267 pounds. They are identical except that the latter has 12 buttons which hold the ends of the chess in place.

b. Each bay of bridge has six stringers: four plain stringers in the middle, and a button stringer on each side. The stringers are positioned by the lugs on top of the transoms.

35. Chess

Chess form the road surface. A chess is 2 inches by 8¾ inches by 13 feet 10 inches. It is made of wood and weighs 65 pounds. It is notched at the ends to fit between the buttons of the button stringer. Each bay of bridge contains 13 chess, which lie across the stringers and are held in place by the buttons on the stringers. Chess are held down by ribands.

36. Steel Riband (Guardrail)

A riband is a steel curb 8⅝ inches high and 10 feet long. It weighs 215 pounds. They are fastened to the button stringers by four J-type riband bolts.

37. Riband Bolt

A riband bolt is a J-type bolt 1 inch in diameter and 8⅝ inches long. It weighs 4½ pounds. A 1½-inch wrench is used to tighten it. The riband bolt fastens the riband to button stringers and ramps. The hook end of the bolt grips the lower flange of the outer I-beam of the button stringer or ramp.

38. End Posts

End posts are used on both ends of each truss of the bridge to take the vertical shear. They are placed only on the story carrying the decking. They are 5-foot columns made of two 4-inch channels and plates welded together. There are two types, male and female, having male and female lugs, respectively. These lugs are secured to the end panels of the bridge by panel pins through holes in the lugs. The male and female end posts weigh 121 and 130 pounds, respectively. End posts have a step to support a transom outside the panel at one end of the bridge. In jacking the bridge, the jack is placed under the step. The lower end of the end post has a half-round bearing block which fits over the bearing.

39. Bearing

a. The bearing spreads the load of the bridge to the base plate. A bearing is a welded steel assembly containing a round bar which, when the bridge is completed, supports the bearing blocks of the end posts (fig. 13). During construction of the bridge, it supports the bearing block of the rocking roller. The bar is divided into three parts by two intermediate sections that act as stiffeners. The bearing is $4\frac{5}{16}$ inches high and weighs 68 pounds.

b. Figure 14 shows the arrangement of the bearings under single-, double-, and triple-truss bridges.

40. Base Plate

The base plate is a welded steel assembly with built-up sides and lifting-hook eyes on the top at each corner. It is used under the bearings to spread the load from bearings over the ground or grillage. The area of the bottom surface of the base plate is $13\frac{1}{2}$ square feet. The base plate weighs 381 pounds and is large enough for the bearings at one corner of either a single-, double-, or triple-truss bridge. Bearings can slide 9 inches longitudinally on the base plate. The numbers 1, 2, and 3 are embossed on the edges of the base plate to indicate the position of the plate under the inner truss of single-, double-, and triple-truss bridges respectively (fig. 14).

41. Ramps

a. Ramps are similar to stringers, but consist of three 5-inch, instead of 4-inch, steel I-beams. They are 10 feet long and are joined by welded braces. The lower surface of the ramp tapers upward near the ends. There are 2 types of ramps: plain ramps weighing 338 pounds,

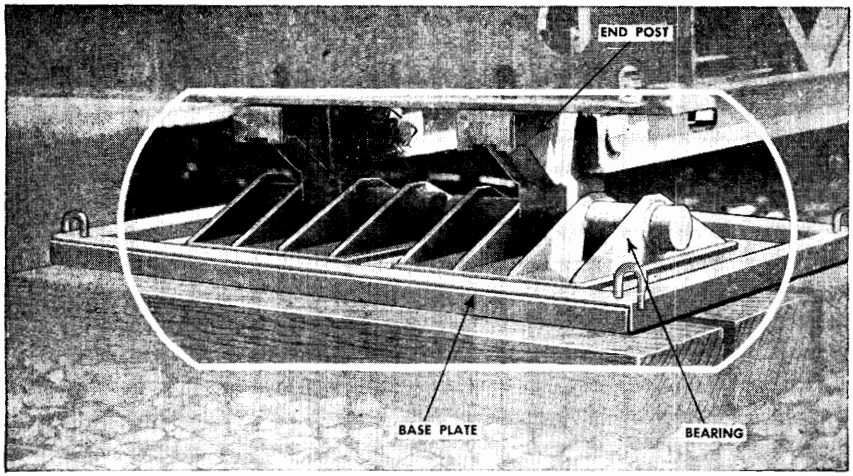


Figure 13. End posts resting on bearings in double-truss bridge.

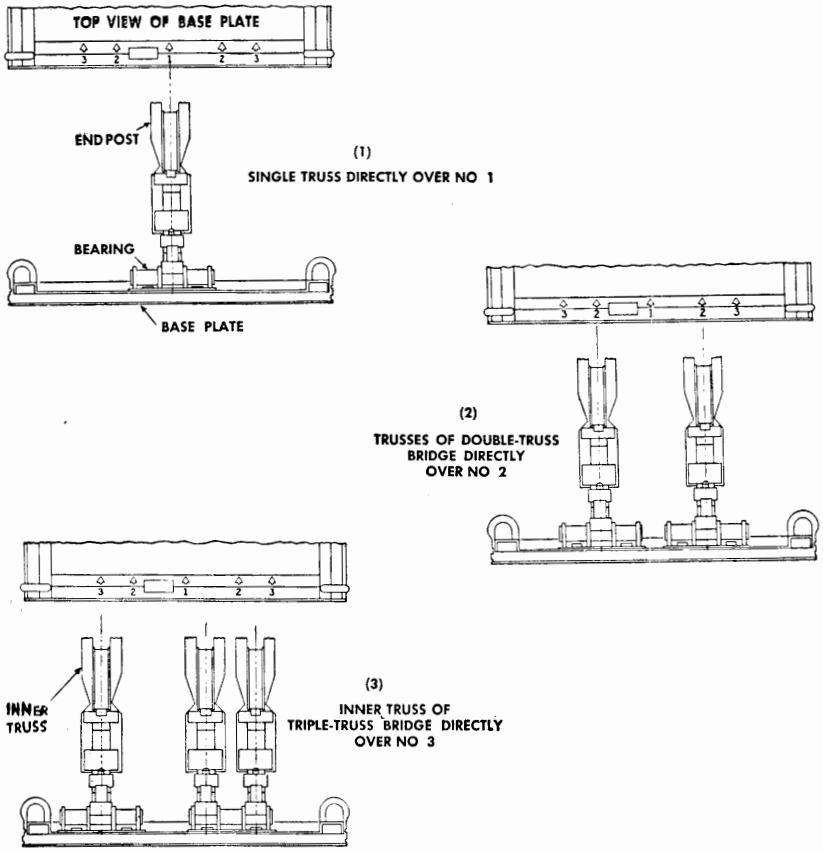


Figure 14. Use of base plate and bearings under single-, double-, and triple-truss bridges.

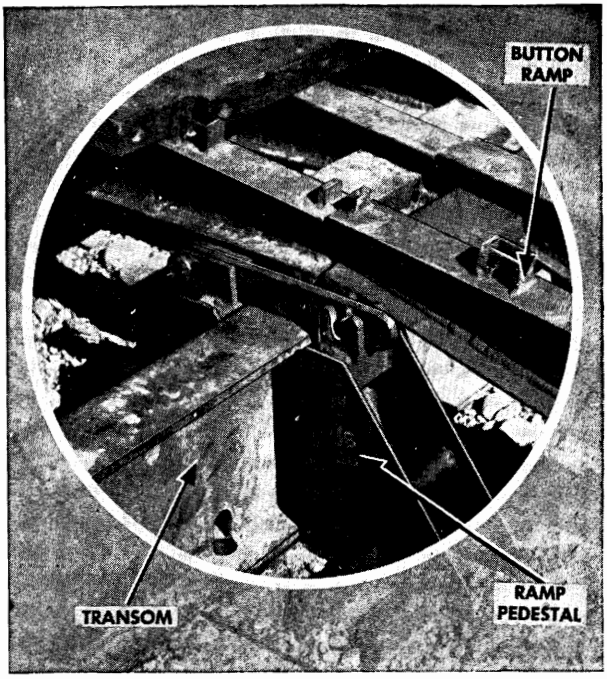


Figure 15. Close-up of ramp pedestal supporting transom.

and button ramps weighing 349 pounds. They are identical except the latter has 12 buttons which hold the ends of the chess in place.

b. Four plain and two button ramps are used as continuations of the stringers and lead from the bridge to the banks. If the slope is too steep, double-length ramps are used, supported at the joint by a transom held in place by four ramp pedestals. For loads of 45 tons or over, the ramps are supported at their midpoints by timber cribbing and wedges. The ends of the ramps fit into lugs on the transoms at the ends of the bridge.

42. Ramp Pedestal

Ramp pedestals are built-up welded steel assemblies weighing 93 pounds. They prevent the transoms supporting multiple-length ramps from overturning and spread the transom load over the ground. They are held in place by spikes or pickets driven through holes in their base plates. They are placed as shown in figure 15.

43. Footwalk

A footwalk is 2 feet 6 inches wide and 10 feet long and weighs 104 pounds. Supported on footwalk bearers, footwalks are laid along the outer sides of the bridge for use by foot troops (fig. 16).

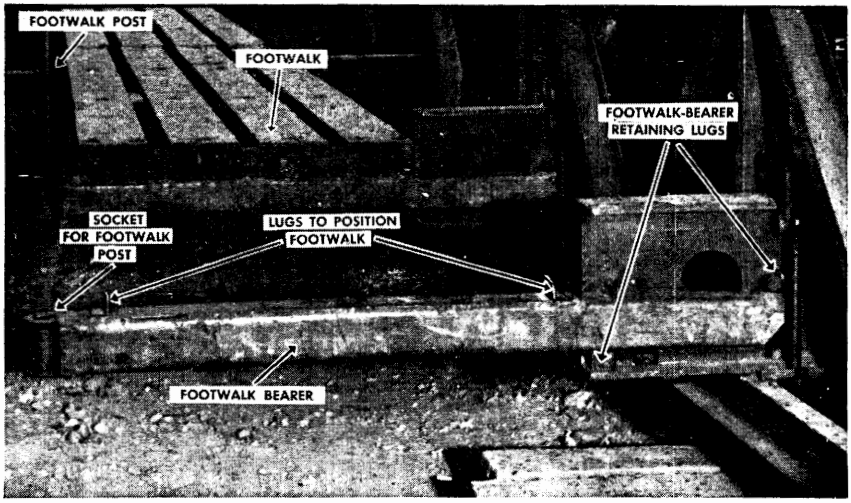


Figure 16. Footwalk and footwalk bearers.

44. Footwalk Bearer

A footwalk bearer is a built-up beam of pressed steel 4 feet long, weighing 22 pounds. Bearers are attached to all transoms except reinforcing transoms, fitting over and under special lugs welded to the web near the ends of the transom (fig. 16). The footwalk fits between lugs on top of the bearers. A socket at the end of the bearer holds the footwalk post.

45. Footwalk Post

A footwalk post 4 feet high and weighing 10 pounds is fitted into every footwalk bearer. Hand ropes are threaded through two eyes on each post and secured either to holdfasts on the banks or to the end footwalk posts.

46. Overhead Bracing Support

The overhead bracing support is used to clamp overhead transoms and sway braces to trusses for overhead bracing of triple-story bridges. The frame is a welded metal assembly that weighs 150 pounds.

Section II. ERECTION EQUIPMENT

47. Rocking Roller

a. The rocking roller, weighing 206 pounds, consists of three rollers housed in a balanced arm which fits over the bearing and is free to

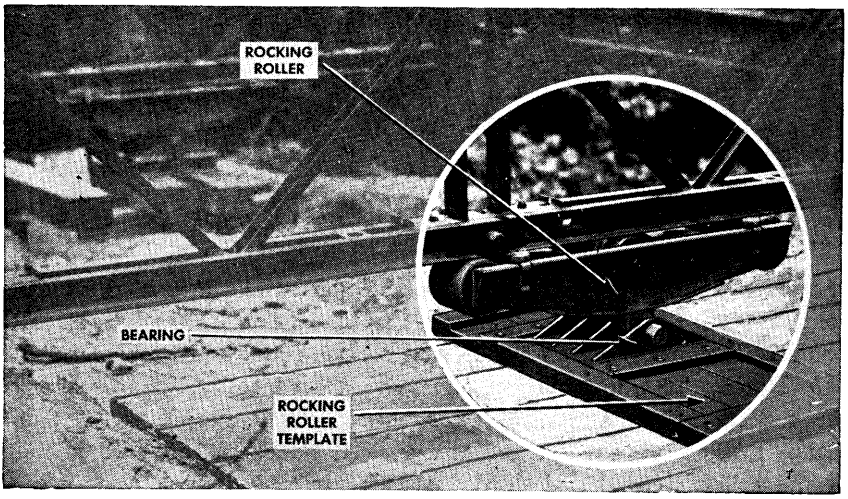


Figure 17. Truss on rocking roller at bank seat.

rock on it. Two side rollers on the flange on each side of the rocking roller frame act as guides for the trusses. The side rollers can be removed from the flanges by removing split pins from spindles underneath the flange; they then remain loosely attached to the frame by a chain.

b. The rollers distribute the bridge load along the bottom chord during launching. One pair of rollers is required for single-truss bridges (fig. 17), and two pairs for double-truss (fig. 18) and triple-truss bridges. On triple-truss bridges, the rollers are placed only under

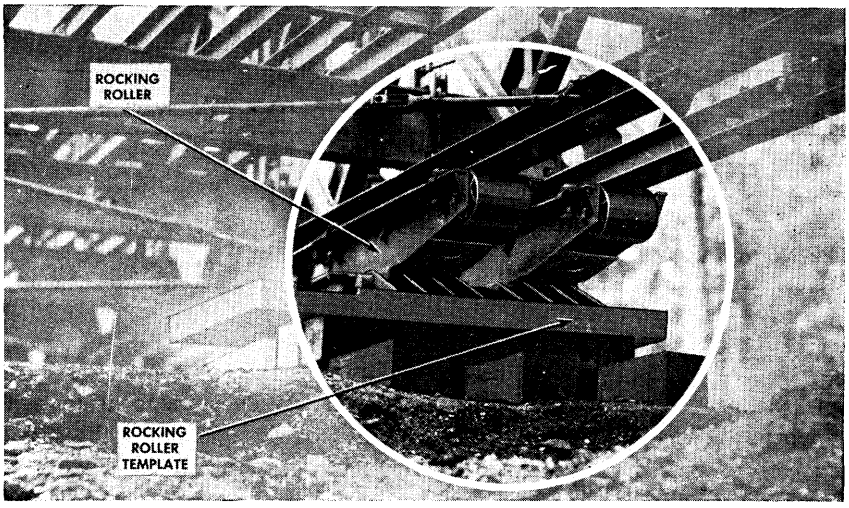


Figure 18. Two rocking rollers used on double-truss bridge.

the inner and second trusses, and the outer side rollers of the outer rocking rollers are removed. One pair of rocking rollers is normally required on the far bank; two pairs are used if the skeleton launching nose is double-truss in any part. The maximum allowable load on one rocking roller is 30 tons.

48. Plain Roller

a. The plain roller is 2 feet wide and consists of a welded housing containing a single roller split in two. The plain roller weighs 116 pounds. The maximum allowable load on one roller is 10 tons.

b. During launching, plain rollers are placed every 25 feet behind the rocking rollers and at other required places except at the bank seats. Trusses of single-truss bridges can be carried on either half of the roller. Second and third trusses of triple-truss bridges are carried on both halves.

49. Jack

a. The jack used to lift the bridge on and off the rocking rollers is a mechanical lifting jack of the type normally used in rigging, railroad, and construction work. It has a lifting range of 15 inches and a capacity on the top of 15 tons. When the weight is carried on its toe, its capacity is only 7½ tons. It weighs 128 pounds.

b. Jacks of different manufacture have different spacing (pitch) between teeth as listed in table 8. In any one jacking operation, all jacks used must have the same tooth pitch so they can be operated in unison.

Table 8. Pitch of Teeth in Panel Bridge Jacks

Manufacturer	Model number	Distance between teeth (pitch) in inches
Joyce	1928	7/16
Simplex	29	15/32
Buda	2815	5/16
Duff-Norton	2815	5/16

50. Jack Shoe

The jack shoe is a welded assembly which fits over the bearing and supports the jack. In jacking under the step of the end posts, the bearing can be placed readily without removing the jack shoe (fig. 19). The jack shoe is 4 3/16 inches high and weighs 36 pounds. It fits over the bearing on the base plate (fig. 20).

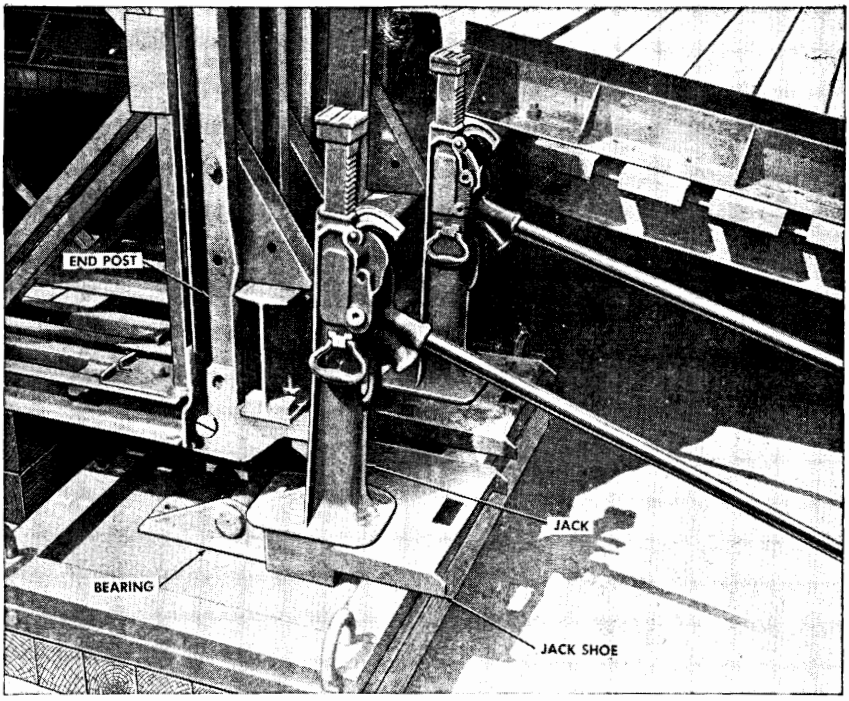


Figure 19. View of jacking operation showing placing of jack, jack shoe, and bearing.

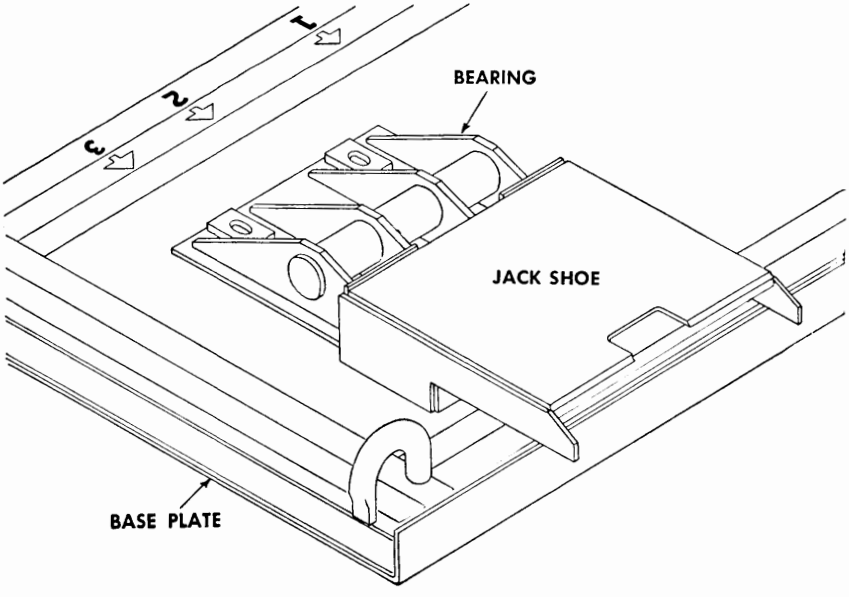


Figure 20. Jack shoe and bearing on base plate.

Table 9. Wrenches Provided with Panel Bridge Set

Wrench	Use
1⅛-inch offset socket wrench	Tighten bracing bolts.
1⅛-inch offset structural wrench	Tighten bracing bolts.
1½-inch offset structural wrench	Tighten riband bolts.
	Tighten sway braces (use tail of wrench).
1⅞-inch offset structural wrench	Tighten chord bolts.
Reversible ratchet-wrench handle with 1⅛-inch and 1⅞-inch sockets.	Tighten bracing bolts (use 1⅛-inch socket).
	Tighten chord bolts (use 1⅞-inch socket).

51. Wrenches

The wrenches provided in the bridge set are listed in table 9.

52. Panel Lever

The panel lever used in erecting the second and third trusses after the first truss is in place over the gap is a wooden bar 7 feet 9 inches long weighing 48 pounds. It has a fulcrum near the center and a lifting link at the end. The lifting link has a swiveling crosspiece which can be readily attached to the top of a panel by passing it through the upper chord and turning it. The upper end of the link slides in a

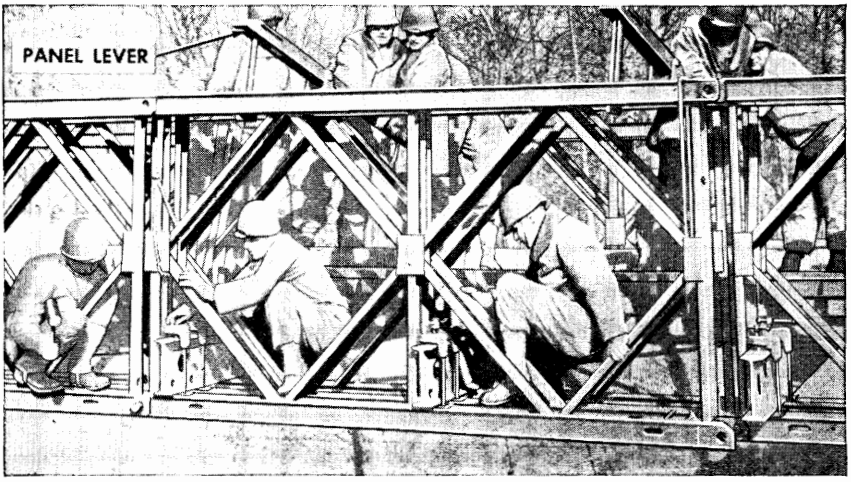


Figure 21. Using panel levers to add outer truss of a triple-single bridge.

slot: the inner end of the slot is used when erecting the second truss and the outer end when erecting the third truss. The fulcrum is always placed on the top of the first truss. Two levers per panel are required, with two men operating each lever (fig. 21).

53. Carrying Bar

A wooden carrying bar 3 feet 6 inches long, reinforced by a steel band at the middle, is used to carry panels and transoms. It weighs 8 pounds.

54. Chord Jack

a. The chord jack consists of two welded steel frames which fit on the top chord and engage with the plates which carry the holes for bracing-frame dowels (fig. 22). Each frame is held down by a bolt through the chord and the frame. A knuckle-threaded screw assembly fits between the frames and is operated by a ratchet lever to force them apart. The lever has a shackle at its end to which a rope can be attached to facilitate operation.

b. When adding a second or third story to a bridge already launched, work should start in the middle and proceed toward the ends. Upper jaws of the second-story panels will be overengaged because of the natural sag of the bridge. The chord jack is used to spread the jaws and allow the upper panel pins to be inserted. For detailed description of use of chord jack, see chapter 12.

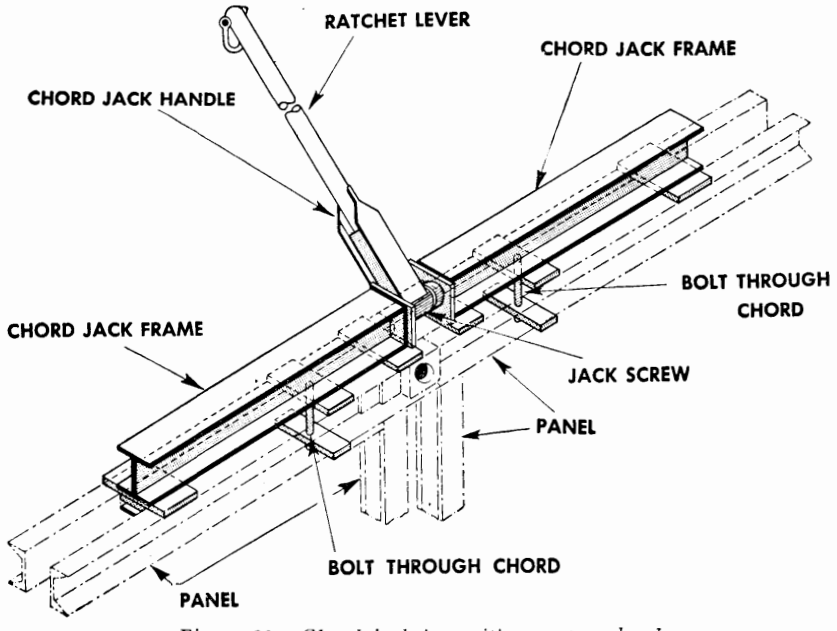


Figure 22. Chord jack in position on top chord.



Figure 23. Using pin extractor in dismantling bridge.

55. Pin Extractor

The pin extractor assists in dismantling the bridge. After the pin has been driven part way out and the recess under the head of the pin is exposed, the pin extractor grips this recess and forces the pin out by a levering action (fig. 23). It is particularly useful for dismantling the third truss of a triple-truss bridge, because the proximity of the second truss makes it impossible to drive the pins out with a hammer.

56. Launching-nose Link MK II

a. The launching-nose link MK II is about 10 inches long and 7 inches wide and weighs 28 pounds. Links consist of two steel frames welded back to back, into which fit the lugs of two panels, joining them. The sides of the links have holes into which panel pins can be inserted. The links lie flush with the underside of the bottom chords of the panels and have a false flange welded on the bottom edge so the bridge can be rolled out on launching rollers. It has a pintle on the top to seat a transom.

b. The launching-nose links overcome the sag occurring when the launching nose is cantilevered over the gap. Using one link on each truss increases the length of the bottom chords of the launching nose

by 7½ inches, thus raising the end of the launching nose by 13½ inches for each bay ahead of the links. The links must not be inserted with more than four bays of the launching nose ahead of them; consequently, the maximum amount of lift that can be obtained from one pair of links is about 54 inches. If a greater lift is required, an additional pair of links can be used in one of the joints between the original pair and the end of the nose, its position depending on how much lift is required (see table 38). The maximum lift obtainable is approximately 94½ inches.

c. The launching-nose links are also used between the upper jaws of span junction posts during the launching of broken-span bridges. This is described in chapter 24.

57. Templates

Two types of templates are provided, one to locate the bearings for the rocking rollers and the other for the plain rollers.

a. Rocking-roller Template. The rocking-roller template weighs 78 pounds and consists of a timber base with timber strips on top which surround two spaces large enough for rocking-roller bearings. At one end of the template are two angle cleats which are used as measuring points. One template is placed on each side of the bridge with 11 feet 6½ inches between cleats.

b. Plain-roller Template. The plain-roller template weighs 22 pounds and consists of a timber base with timber strips on three sides and a steel strip on the fourth side surrounding a space large enough for the base of a single plain roller. It also has two angle cleats at one end for measuring points. When two rollers are used, one under each side of the bridge, the templates are 11 feet 6½ inches apart. When four rollers are used, two under each side of the bridge, two templates are used back to back under each pair and the pairs of templates are 10 feet 10½ inches apart.

CHAPTER 6

TRANSPORTATION AND LOADING

58. General

This chapter discusses methods of stocking, transporting, and ordering equipment for the M2 panel bridge. It describes available sets, both normal and special, and loads for standard transportation. The sets and erection equipment mentioned in this chapter are used to assemble the M2 bridge and the panel crib pier. Chapters 3 and 5 give allowable types of truss construction and a description of the M2 bridge parts. Chapter 25 describes the panel crib pier and gives its uses. Chapter 5 describes the erection equipment for the M2 bridge and the panel crib piers.

59. Sets

a. BASIC BRIDGE SET. Sets for M2 bridges are basic sets used for procurement, export, and stocking of depots. They contain equipment for building the spans described below, plus spares required for depot stock. Parts for standard truck loads (par. 60) are drawn from these basic sets. One basic set minus depot spares can be carried on forty-two 2½-ton trucks of the panel bridge company (T/O & E 5–287). Table 10 lists components of the M2 panel bridge basic set. The set contains equipment to build and launch two 80-foot double-single M2 bridge spans with launching nose *or* one 130-foot double-double M2 bridge span with launching nose, *plus depot spares.* Figure 8 shows individual bridge parts. Figure 9 shows principal items of erection equipment.

Table 10. Bridge, Fixed, Steel Panel, Bailey Type M2, Set Stock No. 210.550[1]

Nomenclature	Stock number	Average unit weight (lb)	Set quantity	Total weight (lb)
Section A. Bridge parts				
Bag, transport	24.1882.865.500	2	500	1,000
Bearer, footwalk	79.1700.500.500	23	80	1,840
Bearing, 4 5/16" high	79.1785.542.500	68	16	1,088
Bolt, bracing	79.1990.500.500	1	1200	1,200
Bolt, chord	79.2010.500.500	7.5	400	3,000
Bolt, end-post (spare)	79.2050.500.500	0.75	24	18
Bolt, riband, guardrail, "J"	79.2080.500.700	4.5	440	1,980
Brace, sway, M2	79.2220.500.600	68	64	4,352

Table 10. Bridge, Fixed, Steel Panel, Bailey Type, M2, Set Stock No. 210,550[1]—Continued

Nomenclature	Stock number	Average unit weight (lb)	Set quantity	Total weight (lb)
Chess, M2	79.2800.600.500	65	336	21,840
Chest, delineation equipment, stream crossing for carrying:	42.3220.500.500	60	2	120
Box, sign, interior, illuminated, 4″ x 15″ message	17.1828.600.500	6	4	24
Marker, luminous, radioactive	42.5848.200.170	0.13	200	26
Clamp, transom	79.3015.800.500	7	600	4,200
Footwalk	79.4000.500.500	104	32	3,328
Frame, bracing	79.4015.500.500	44	64	2,816
Panel	79.5850.500.500	577	126	72,702
Pedestal, ramp, M2	79.5900.500.600	93	16	1,488
Picket, steel	79.6005.500.500	12	40	480
Pin, panel	79.6135.490.500	6.1	862	5,258
Pin, panel, short	79.6135.490.400	5.8	38	220
Pin, safety	79.6135.500.500	0.13	1000	130
Pin, sway-brace (spare)	79.6135.800.500	1.1	50	55
Plate, base	79.6403.500.500	381	8	3,048
Plate, tie	79.6476.100.500	3.5	42	147
Post, end, female	79.6655.390.500	130	16	2,080
Post, end, male	79.6655.400.500	121	16	1,936
Post, footwalk	79.6655.470.500	10	80	800
Raker	79.7090.100.400	22	64	1,408
Ramp, button	79.7200.500.500	348	16	5,568
Ramp, plain	79.7210.500.500	338	32	10,816
Riband, guardrail, steel	79.7270.500.700	215	48	10,320
Rope, sisal, ⅝″ x 150′, handrail	21.7670.500.060	20	4	80
Stringer, button	79.8260.500.500	267	32	8,544
Stringer, plain	79.8280.500.500	260	64	16,640
Support, overhead-bracing[2]	79.8361.500.500	150	[2]	[2]
Transom, M2	79.8995.360.600	618	56	34,608
Total section A				223,160
Section B. Erection equipment				
Bar, carrying	79.1500.500.500	8	100	800
Extractor, pin	79.3600.500.500	18	4	72
Hammer, rawhide-faced	41.4317.200.430	4.5	45	203
Holdfast, with 9 pickets	79.4315.500.500	160	12	1,920
Jack, chord	79.4600.500.500	82	12	984
Jack, ratchet-lever, 15-ton[3]	41.4944.300.155	128	10	1,280
Lever, panel	79.5100.500.500	48	12	672
Link, launching-nose, Mk II	79.5180.500.500	28	24	692
Mat, airplane-landing, steel bar-and-rod type, light (sq ft)	89.5370.100.700	1.9	2160	4,104
Nail, wire, steel, 40d (lb)	42.6028.300.400		300	300
Roller, plain	79.7350.500.500	116	12	1,392
Roller, rocking	79.7360.500.500	206	12	2,472

Table 10. Bridge, Fixed, Steel Panel, Bailey Type, M2, Set Stock No. 210.550[1]*—Continued*

Nomenclature	Stock number	Average unit weight (lb)	Set quantity	Total weight (lb)
Rope, lashing, sisal, 5/8" x 25'	21.7670.500.060	3.3	80	264
Shoe, jack, 4 3/16" high	79.7715.500.400	36	8	288
Sledge, blacksmith, 8-lb	41.7531.500.080	8	12	96
Spike, 3/8" x 8" (lb)	42.8488.040.080	.....	20	20
Tackle, heavy, consisting of:				
Block, triple, for 1" rope	19.3552.110.816	20	4	80
Rope, sisal, 1" x 600'	21.7670.500.100	156	2	312
Shackle, anchor, pin, steel, 1"	12.4872.500.100	5	4	20
Sling, wire-rope, 5/8" x 8', with eye at one end and hook at other end	22.5307.132.208	12	4	48
Tackle, light, consisting of:				
Block, snatch, for 3/4" rope	19.7532.270.612	6.3	4	25
Block, double, for 3/4" rope	19.3512.110.612	8	8	64
Rope, lashing, sisal, 5/8" x 25'	21.7670.500.060	3.3	8	26
Rope, sisal, 3/4" x 600'	21.7670.500.070	102	2	204
Template, plain-roller	79.8400.300.500	22	12	264
Template, rocking-roller	79.8400.700.500	78	8	624
Timber, grillage, 6" x 6" x 4'-6"	79.8500.300.600	52	144	7,488
Timber, packing, 3" x 6" x 4'-6"	79.8500.700.600	18	48	864
Wedge, hardwood (pr)	79.9515.300.500	12	16	192
Wrench, ratchet, reversible, with 1 1/8" and 1 7/8" sockets, for 3/4" and 1 1/4" bolts	41.9696.110.170	13	30	390
Wrench, socket, offset 90 degrees, 1 1/8" for 3/4" bolts	41.9750.600.110	12	40	480
Wrench, structural, 1 1/8" for 3/4" bolts	41.9801.110.130	2	60	120
Wrench, structural, 1 1/2" for 1" bolts	41.9801.015.100	4.7	30	141
Wrench, structural, 1 7/8" for 1 1/4" bolts	41.9801.170.187	5.6	40	224
Total section B	.....	.....	.....	27,125

[1] One bridge set contains equipment to erect two 80-foot DS bridges with launching nose *or* one 130-foot DD bridge with launching nose.

[2] Overhead-bracing support is not supplied in set. It must be procured separately.

[3] All jacks in one set must have same tooth pitch. Joyce model No. 1928, Simplex model No. 29, and Buda model No. 2815 jacks have different tooth pitches and are not interchangeable. Duff-Norton model No. 2815 jack has same pitch as and is interchangeable with Buda model No. 2815 jack.

b. CONVERSION SET NO. 3, PANEL CRIB PIER, M2. Conversion set No. 3 is used with equipment from the basic set to build panel crib piers. Table 11 lists component parts of conversion set No. 3. These parts are carried in two crib-pier truck loads. Figure 219 shows the location of principal special parts in a pier. Figures 220 to 229 show each individual special part.

*Table 11. Bridge Conversion Set No. 3, Bailey Type, Panel Crib Pier, Fixed, M2, Set Stock No. 260,030**

Nomenclature	Stock number	Unit weight (lb)	Set quantity	Total weight (lb)
Bag, transport	24.1882.865.500	2	30	60
Bearing, crib	79.1785.525.500	37	24	888
Bearing, junction-link	79.1785.545.500	217	6	1302
Bolt, bracing	79.1990.500.500	1	36	36
Bolt, chord	79.2010.500.500	7.5	8	60
Brace, sway, M2	79.2220.500.600	68	12	816
Capsill, crib	79.2590.500.500	251	12	3012
Chess, junction, M2	79.2815.500.550	149	4	596
Clamp, chord	79.3015.250.500	11	52	572
Clamp, transom	79.3015.800.500	7	32	224
Frame, bracing	79.4015.500.500	44	4	176
Link, junction	79.5180.300.550	36	6	216
Link, launching-nose, Mk II	79.5180.500.550	28	6	168
Pin, panel	79.6135.490.500	6.1	120	732
Pin, safety	79.6135.500.500	.13	200	26
Pin, sway-brace (spare)	79.6135.800.500	1.1	2	2
Plate, tie	79.6476.100.500	3.5	16	56
Post, junction, span, female	79.6655.600.500	202	6	1212
Post, junction, span, male	79.6655.600.550	194	6	1164
Raker	79.7090.100.400	22	16	352
Total				11,670

* One bridge conversion set No. 3 makes two crib-pier loads, and with extra panel and transom loads builds the following piers:

Pier	Unit truck loads
31′–7″ TT (DV–DV–DV)	2 crib pier 4 panel 2 transom
21′–7″ TD (DV–DV)	2 crib pier 3 panel 1 transom
21′–7″ DD (DV–SV) 17′–0″ TD (DV–SH)	2 crib pier 2 panel 1 transom

60. Standard Truck Loads

a. TYPES OF TRANSPORTATION. Panel-bridge parts are normally carried on the 2½-ton LWB trucks and 2½-ton LWB cab-over-engine (COE) trucks of the panel bridge company (table 23). COE trucks are for transom loads only.

b. FEATURES. The panel-bridge loads described in this chapter have the following features:

(1) All loads are for 2½-ton trucks without trailers, which are furnished to the panel bridge company that normally transports the bridge.

(2) A minimum number of different loads are employed. There are five basic bridge loads (accessory, ramp, decking, panel, and transom), and four supplementary loads (footwalk, grillage, overhead bracing, and crib pier) for heavy and special construction.

(3) All loads are *combat loads,* and provide all the equipment required to build the bridge from the trucks, if the loads arrive at the site in the order given in table 27. The loads can be used in various economical combination to build various types and spans of bridge. They make it possible to determine the exact transportation and equipment required for any bridge, simplify stock control and placing of orders, and minimize errors in delivery of equipment to the bridge site.

c. LOADS FOR BRIDGE SET. M2 bridge parts are transported in the standard truck loads listed below.

Truck load No. 1 (2½-ton truck)—Accessory load (table 12).
Truck load No. 2 (2½-ton truck)—Ramp load (table 13).
Truck load No. 3 (2½-ton truck)—Decking load (table 14).
Truck load No. 4 (2½-ton truck)—Panel load (table 15).
Truck load No. 5 (2½-ton COE truck)—Transom load (table 16).
Truck load No. 6 (2½-ton truck)—Footwalk load (table 17).
Truck load No. 7 (2½-ton truck)—Grillage load (table 18).
Truck load No. 7A (2½-ton truck)—Supplemental grillage load (table 19). (For heavy bridges only, see tables 23 and 25.)
Truck load No. 8 (2½-ton truck)—Overhead-bracing load (table 20). (For triple-story bridge only.)

d. LOADS FOR CONVERSION SET NO. 3. Conversion set No. 3 is carried in two crib-pier loads. The following truck load is standard.

Truck load No. 9 (2½-ton truck)—Crib-pier load (table 21).

e. MASTER TABLES. (1) Table 22 gives bridge construction capabilities of the standard truck loads.

(2) Table 23 gives the number of standard truck loads required to build each type and size of bridge. Table 24 gives the numbers of loads required to build each type of crib pier.

Table 12. Truck Load No. 1—Accessory Load (2½-ton Truck)
(1 load per bridge platoon; 2 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
7	Bag, transport	2	14
8	Bar, carrying	8	64
2	Box, sign, interior-illuminated	6	12
1	Chest, delineation equipment, stream crossing	60	60
2	Extractor, pin (2 per bag)	18	36
6	Holdfast, with 9 pickets	160	960
3	Jack, chord	82	246
5	Jack, ratchet-lever	128	640
6	Lever, panel	48	288
6	Link, launching-nose, Mk II	28	168
100	Marker, luminous, radioactive, type II	13	13
150 lb	Nail, 40d (in bag)	...	150
6	Roller, plain	116	696
6	Roller, rocking	206	1236
4	Shoe, jack	36	144
6	Sledge, blacksmith's	8	48
5 lb	Spike, 8″ (in bag)	...	5
1	Tackle, heavy, consisting of: 2 block, triple, for 1″ rope 1 rope, sisal, 1″ x 600′ 2 shackle, 1″ 2 sling, wire-rope, ⅝″ x 8′, w/eye at one end and hook at other end	300	300
1	Tackle, light, consisting of: 2 block, snatch, for ¾″ rope 4 block, double, for ¾″ rope 4 lashing, ⅝″ x 25′ 1 rope, sisal, ¾″ x 600′	300	300
6	Template, plain-roller	22	132
4	Template, rocking-roller	78	312
8	Wedges, hardwood, pair	12	96
8	Wrench, ratchet, w/1⅛″ and 1⅜″ sockets (6 per bag)	13	104
	Total	.....	6024

Table 13. Truck Load No. 2—Ramp Load (2½-ton Truck)
(4 loads per bridge platoon; 8 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
7	Bag, transport	2	14
2	Bearing	68	136
2	Bolt, end-post (spare) (in bar)	1	2
9	Bolt, riband, guardrail (in bag)	4.5	41
2	Brace, sway, M2	68	136
14	Chess, M2	65	910
1	Frame, bracing (spare)	44	44
2	Lashing, ⅝" x 25' (in bag)	5	10
2	Pedestal, ramp, M2	93	186
6	Pin, panel, short (in 1 bag)	5.8	35
6	Pin, safety (in 1 bag)	0.1	1
3	Pin, sway-brace (spare) (in bag)	1	3
5	Picket, steel	12	60
1	Plate, base	381	381
2	Post, end, female	130	260
2	Post, end, male	121	242
2	Ramp, button	348	696
4	Ramp, plain	338	1352
2	Riband, guardrail, steel	215	430
	Total		4939

Table 14. Truck Load No. 3—Decking Load (2½-ton Truck)
(4 loads per bridge platoon; 8 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
5	Bag, transport	2	10
20	Bolt, bracing (in bag)	1	20
18	Bolt, riband, guardrail (in bag)	4.5	81
6	Brace, sway, M2	68	408
28	Chess, M2	65	1820
8	Raker	22	176
4	Riband, guardrail, steel	215	860
4	Stringer, button	267	1068
8	Stringer, plain	260	2080
6	Timber, packing, 3" x 6" x 4'6"	18	108
2	Wrench, structural, 1⅛" (in 1 bag)	2	4
2	Wrench, structural, 1½" (in 1 bag)	5	10
	Total		6645

Table 15. Truck Load No. 4—Panel Load (2½-ton Truck)
(6 loads per bridge platoon; 4 loads per headquarters platoon; 16 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
11	Bag, transport	2	22
2	Bar, carrying	8	16
35	Bolt, bracing (in bag)	1	35
15	Bolt, chord (in 2 bags)	7.5	113
4	Frame, bracing	44	176
2	Hammer, hide-faced	4.5	9
2	Lashing, ⅝″ x 25′ (in bag)	5	10
9	Panel	577	5193
30	Pin, panel (in 3 bags)	6.2	186
30	Pin, safety (in 3 bags)		
3	Plate, tie	3.5	11
2	Wrench, socket, 1⅛″ (in bag)	2	4
2	Wrench, structural, 1⅛″ (in 1 bag)	2	4
2	Wrench, structural, 1⅞″ (in 1 bag)	6	12
	Total		5791

Table 16. Truck Load No. 5—Transom Load (2½-ton COE Truck)
(3 loads per bridge platoon; 2 loads per headquarters platoon; 8 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
8	Bag, transport	2	16
2	Bar, carrying	8	16
50	Clamp, transom (in 5 bags)	7	350
2	Lashing, ⅝″ x 25′ (in bag)	5	10
8	Transom M2	618	4944
	Total		5336

Table 17. Truck Load No. 6—Footwalk Load (2½-ton Truck)
(1 load per platoon; 2 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
2	Bag, transport	2	4
40	Bearer, footwalk	23	920
16	Footwalk	104	1664
4	Lashing, ⅝″ x 25′ (in 2 bags)	5	20
40	Post, footwalk	10	400
2	Rope, handrail, ⅝″ x 150′	25	50
	Total		3058

Table 18. Truck Load No. 7—Grillage Load (2½-ton Truck)
(1 load per bridge platoon; 2 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
1080 sq ft	Mat, landing, steel, light bar end rod.....	1.9	2052
72	Timber, grillage, 6″ x 6″ x 4′6″.....	52	3744
	Total	.....	5796

*Table 19. Truck Load No. 7A—Supplemental Grillage Load (2½-ton Truck)**

Quantity	Item	Weight (lb)	
		Unit	Total
360 sq ft	Mat, landing, steel, light bar and rod.....	1.9	684
6	Ramp, plain	338	2028
63	Timber, grillage, 6″ x 6″ x 4′6″.....	52	3276
	Total	.....	5988

* This load is made up of plain ramps from two of the unused ramp loads. It is used for heavy bridges that require more grillage than is supplied in load No. 7.

Table 20. Truck Load No. 8—Overhead-bracing Load (2½-ton Truck)[1]

Quantity	Item	Weight (lb)	
		Unit	Total
16	Bag, transport	2	32
60	Bolt, bracing (in bag)	1	60
144	Bolt, chord (12 per bag).....	7.5	1080
16	Brace, sway, M2[2]	68	1088
10	Frame, bracing	44	440
20	Support, overhead-bracing[2]	150	3000
	Total	.....	5700

[1] Two loads required for a triple story bridge.

[2] Overhead-bracing supports, set stock number 79.8361.500.500, are not included in bridge sets. They are class IV equipment and must be requisitioned separately. When overhead-bracing supports are not used and triple story bridges are braced by underslung transoms in inverted third-story panels, overhead-bracing loads are eliminated and 13 sway braces are added to each transom load. Total transom load then weighs 6220 pounds.

Table 21. Truck Load No. 9—Crib-pier Load (2½-ton Truck)
(2 loads per headquarters platoon; 2 loads per company)

Quantity	Item	Weight (lb)	
		Unit	Total
20	Bag, transport	2	40
12	Bearing, crib	37	444
3	Bearing, junction-link	217	651
30	Bolt, bracing (in bag)	1	30
6	Bolt, chord (in bag)	7.5	45
6	Brace, sway, M2	68	408
6	Capsill, crib	251	1506
2	Chess, junction, M2	149	298
26	Clamp, chord (in 5 bags)	11	286
24	Clamp, transom (in 3 bags)	7	168
3	Frame, bracing	44	132
3	Link, junction	36	108
4	Link, launching-nose, Mk II	28	112
72	Pin, panel (in 6 bags)	6	432
100	Pin, safety (in bag)	0.1	10
2	Pin, sway-brace, spare (in bag with chord bolts)	1	2
8	Plate, tie	3.5	28
3	Post, junction, span, female	202	606
3	Post, junction, span, male	194	582
8	Raker	22	176
	Total		6064

*Table 22. Capabilities of Standard Truck Loads**

Standard truck load Number	Name	Loads required
		Basic bridge loads
1	Accessory load	1 per bridge 30′—70′ long. 2 per bridge 80′—150′ long. 3 per bridge 160′—200′ long.
2	Ramp load	4 per bridge (20′ of ramp at each end).
3	Decking load	1 per 20′ of bridge or nose.
4	Panel load	1 per 28′ of SS bridge. 1 per 17′ of DS bridge. 1 per 12′ of TS bridge. 1 per 9′ of DD bridge. 1 per 6.5′ of TD bridge. 1 per 6.5′ of DT bridge. 1 per 4′ of TT bridge.
5	Transom load	1 per 25′ of bridge *without* overhead bracing. 1 per 20′ of bridge *with* overhead bracing.
		Supplementary loads
6	Footwalk load	1 per 80′ of bridge.
7	Grillage load	See table 23.
8	Overhead-bracing load	2 per triple story bridge.
9	Crib-pier load	See table 24.

* These requirements assume use of four ramp bays and a launching nose.

Table 23. Number of standard truck loads required to build different spans of panel bridge, Bailey type, M2, with nose, using transportation of panel bridge company

Bridge		Number of unit truck loads									Total number of vehicles		Number of bridges that can be carried using transportation of panel bridge company[1]			
Span (ft.)	Type	Accessory	Ramp	Decking	Panel	Transom	Footwalk	Grillage[2]		Overhead bracing	2½ ton LVB	2½ ton COE	One platoon	Two platoons	One platoon and headquarters	One company
		2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk						
		Load No. 1	Load No. 2	Load No. 3	Load No. 4	Load No. 5	Load No. 6	Load No. 7	Load No. 7A	Load No. 8						
30	SS	1	4	2	2	2	1	1			11	2	1	3	2	3
40	SS	1	4	2	2	2	1	1			11	2	1	3	2	3
50	SS	1	4	3	2	2	1	1			12	2	1	2	1	3
	DS	1	4	3	3	2	1		3		15	2	1	2	1	2
60	SS	1	4	3	3	3	1	1			13	3	1	2	1	3
	DS	1	4	3	4	3	1		3		16	3	1	2	1	2
70	SS	1	4	4	3	3	1	1			14	3	1	2	1	2
	DS	1	4	4	5	3	1	1			16	3	1	2	1	2
80	SS	1	4	4	3	3	1	1			14	3	1	2	1	2
	DS	1	4	4	5	3	1	1			16	3	1	2	1	2
	TS	2	4	4	7	3	1		3		21	3		1	1	1
90	SS	1	4	5	4	4	2	1			17	4		1	1	2
	DS	1	4	5	6	4	2	1			19	4		1	1	2
	TS	2	4	5	8	4	2		3		24	4		1		1
100	SS	1	4	5	4	4	2	1			17	4		1	1	2
	DS	1	4	5	6	4	2	1			19	4		1	1	2
	TS	2	4	5	9	4	2	1			23	4		1	1	1
	DD	2	4	5	11	4	2		3		27	4		1		1

110	DS	1	4	6	7	4	2	1			21	4		1	1	1
	TS	2	4	6	10	4	2	1			25	4		1		1
	DD	2	4	6	12	4	2		3		29	4		1		1
	TD	2	4	6	17	4	2		3		34	4		1		1
120	DS	1	4	6	8	5	2	1			22	5		1	1	1
	TS	2	4	6	10	5	2	1			25	5		1		1
	DD	2	4	6	13	5	2		3		30	5		1		1
	TD	2	4	6	19	5	2		3		36	5				1
130	DS	1	4	7	8	5	2	1			23	5		1	1	1
	TS	2	4	7	11	5	2	1			27	5		1		1
	DD	2	4	7	14	5	2	2			31	5		1		1
	TD	2	4	7	21	5	2		3		39	5				1
	DT	2	4	7	21	7	2	[3]		2	38	7				1
140	DS	1	4	7	9	5	2	1			24	5		1		1
	TS	2	4	7	12	5	2	2			29	5		1		1
	DD	2	4	7	16	5	2	2			33	5		1		1
	TD	2	4	7	22	5	2		3		40	5				1
	DT	2	4	7	22	7	2		3	2	42	7				
150	TS	2	4	8	13	6	2	1			30	6		1		1
	DD	2	4	8	17	6	2		3		36	6				1
	TD	2	4	8	24	6	2		3		43	6				
	DT	2	4	8	24	7	2		3	2	45	7				
160	TS	2	4	8	14	6	2	1			31	6		1		1
	DD	3	4	8	18	6	2	2			37	6				1
	TD	3	4	8	25	6	2		3		45	6				
	DT	2	4	8	26	8	2	[3]		2	44	8				
	TT	3	4	8	36	8	2	[3]		2	55	8				
170	DD	3	4	9	19	6	3		3		41	6				
	TD	3	4	9	27	6	3		3		49	6				
	DT	2	4	9	27	8	3	[3]		2	47	8				

Table 23. Number of standard truck loads required to build different spans of panel bridge, Bailey type, M2, with nose, using transportation of panel bridge company—Continued.

Bridge		Number of unit truck loads									Total number of vehicles		Number of bridges that can be carried using transportation of panel bridge company[1]			
Span (ft.)	Type	Accessory	Ramp	Decking	Panel	Transom	Footwalk	Grillage[2]		Overhead bracing	2½ ton LVB	2½ ton COE	One platoon	Two platoons	One platoon and headquarters	One company
		2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk						
		Load No. 1	Load No. 2	Load No. 3	Load No. 4	Load No. 5	Load No. 6	Load No. 7	Load No. 7A	Load No. 8						
170	TT	3	4	9	38	8	3	[3]		2	59	8				
180	DD	3	4	9	20	6	3	2			41	6				
	TD	3	4	9	28	6	3		3		50	6				
	DT	3	4	9	28	9	3	[3]		2	49	9				
	TT	3	4	9	42	9	3	[3]		2	63	9				
190	TD	3	4	10	30	7	3		3		53	7				
	DT	3	4	10	30	9	3		3	2	55	9				
	TT	3	4	10	44	10	3	[3]		2	66	10				
200	DT	3	4	10	30	9	3		3	2	55	9				
	TT	3	4	10	48	10	3	[3]		2	70	10				
210	DT	3	4	11	31	9	3		3	2	57	9				
	TT	3	4	11	52	11	3	[3]		2	75	11				

[1] Based on total number of trucks in panel bridge company (see below).
[2] Grillage requirements based on soil with a safe bearing pressure of 2 tons per square foot.
[3] Grillage supplied will not support these bridges and must be improvised in the field (see chapter 10).

Number of loads normally carried by panel bridge company

Load No.	Type of load	Number of loads			
		One platoon	Two platoons	One platoon and headquarters	One company
1	Accessory load	1	2	1	2
2	Ramp load	4	8	4	8
3	Decking load	4	8	4	8
4	Panel load	6	12	10	16
5	Transom load	3	6	5	8
6	Footwalk load	1	2	1	2
7	Grillage load	1	2	1	2
7A	Grillage load				
8	Overhead-bracing load				
9	Crib-pier load			2	2
	Total trucks	20	40	28	48

Table 21. Panel crib piers that can be built using standard Truck Loads

Pier			Number of standard truck loads			
			Accessory	Panel	Transom	Crib pier
Height	Type (See ch 25)	Position of rocker	2½-ton trk Load No. 1	2½-ton trk Load No. 4	2½-ton trk Load No. 5	2½-ton trk Load No. 9
6′– 3½″	SS(1H)	At base of pier	1	1	1	1
7′– 2½″	SS(1H)					
10′–10½″	SS(2V)					
	DS(2V)					
11′– 2½″	SS(1V)					
	DS(1V)					
	TS(1V)					
11′– 7¼″	SS(1V)					
6′– 6½″	SS(1H)	At top of pier	1	1	1	2
	DS(1H)					
	TS(1H)					
11′– 3″	SS(1V)					
	DS(1V)					
	TS(1V)					
11′– 7″	SS(2V)					
	DS(2V)					
16′– 6½″	SD(1H–1V)					
	DD(1H–1V)					
17′– 0″	SD(2V–1H)					
21′– 7″	DD(2V–1V)					
6′– 3½″	DS(1H)	At base of pier				
	TS(1H)					
7′– 2½″	DS(1H)					
	TS(1H)					
11′– 7¼″	DS(1V)					
	TS(1V)					
10′–10½″	TS(2V)	At base of pier	1	2	1	1
11′– 7″	TS(2V)	At top of pier	1	2	1	2
16′– 6½″	TD(1H–1V)					
17′– 0″	DD(2V–1H)					
	TD(2V–1H)*					
21′– 3″	TD(1V–1V)					
21′– 7″	DD(2V–1V)					
	TD(2V–1V)*					
	DD(2V–2V)					
21′– 7″	TD(2V–2V)*	At top of pier	1	3	1	2
31′– 7″	DT(2V–2V–2V) ...	At top of pier	1	3	2	2
31′– 7″	TT(2V–2V–2V)* ..	At top of pier	1	4	2	2
41′– 7″	DQ(4V–4V–2V–2V)	At top of pier	1	6	3	4
51′– 7″	D5(4V–4V–2V–2V–2V)	At top of pier	1	7	4	5
41′– 7″	TQ(4V–4V–2V–2V)	At top of pier	1	9	3	6
51′– 7″	T5(4V–4V–2V–2V–2V)	At top of pier	1	10	4	6

* Most economical loadings. Percentage of extra parts carried is 12% or less.

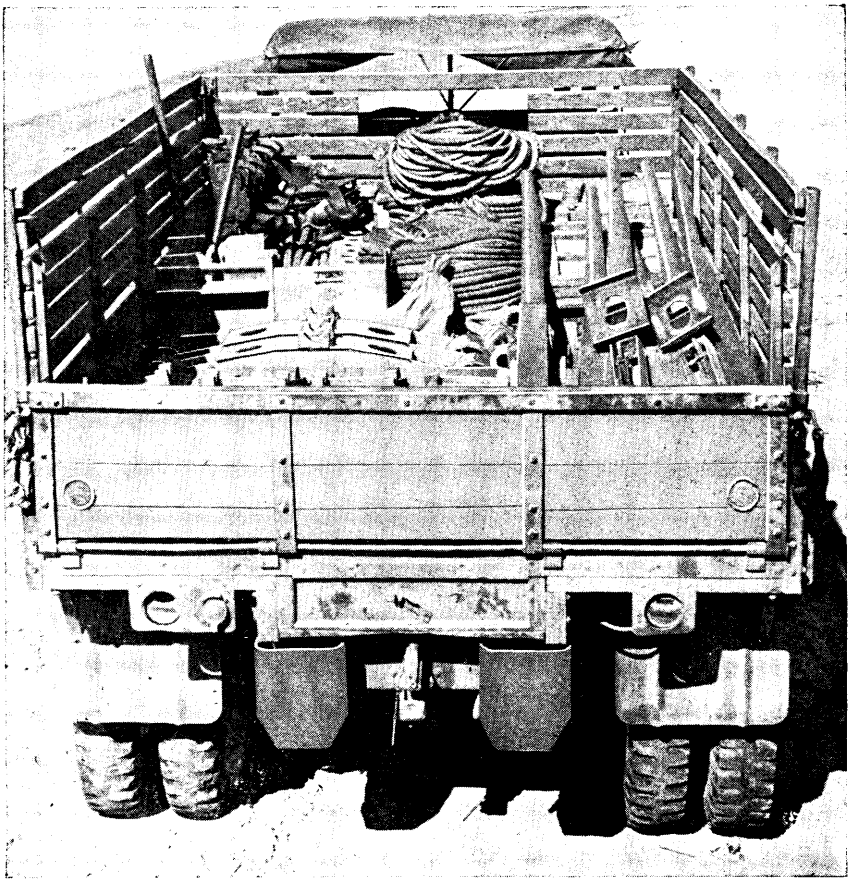


Figure 21. Truck load No. 1—Accessory load on 2½-ton LWB truck.

f. Loading Parts. (1) *General.* Chapter 8 describes loading parties and gives the time required for loading and unloading trucks. To increase construction speed and insure stability in transportation, the following points should be observed in making up truck loads:

(*a*) Load panels flat with female ends toward rear of truck so they can be unloaded and carried directly to bridge.

(*b*) Cut binding wire on new parts such as sway braces before loading on trucks.

(*c*) If footwalks are unessential and men and erection time are critical, supply footwalks for one side of bridge only or omit them.

(2) *Individual trucks.* (*a*) *Truck load No. 1 — Accessory load* (fig. 24). This load contains a large number of miscellaneous parts. They should be loaded so the most frequently used parts are readily accessible without removing the entire load.

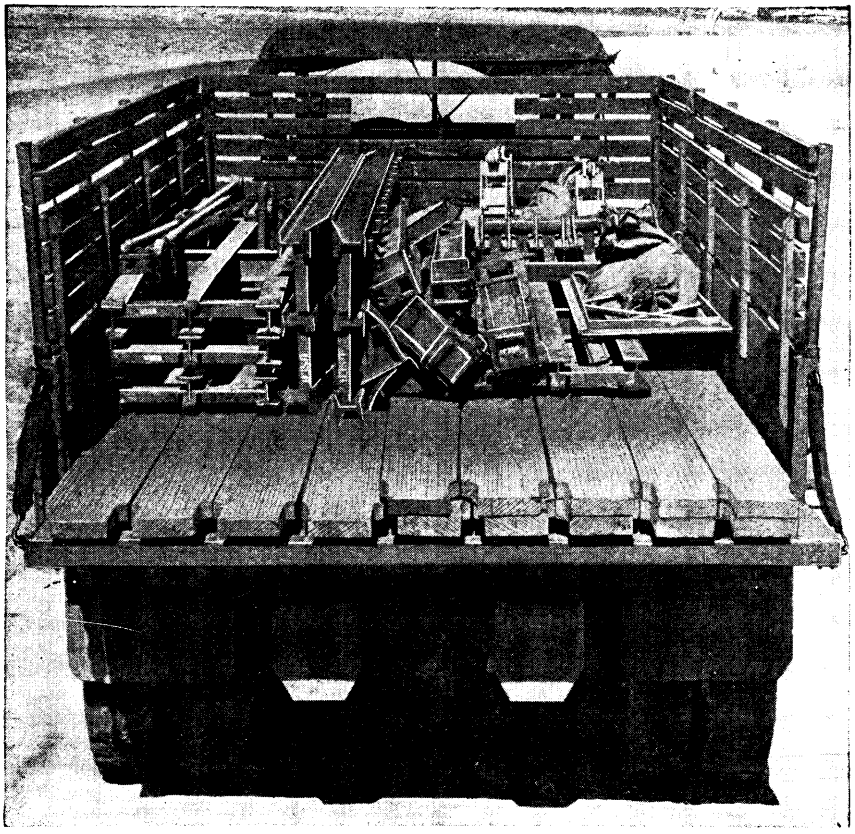


Figure 25. Truck load No. 2—Ramp load on 2½-ton LWB truck.

(*b*) *Truck load No. 2 — Ramp load* (fig. 25). No special precautions are necessary for loading this load.

(*c*) *Truck load No. 3 — Decking load* (fig. 26). Parts in this load should be lashed down to prevent shifting during transport.

(*d*) *Truck load No. 4 — Panel load* (fig. 27). The vertical panels in this load are lashed across the horizontal panels and to the side of the truck. Panels are secured to the front of the body with lashings and a carrying bar as shown in figure 28.

(*e*) *Truck load No. 5 — Transom load* (fig. 29). Transoms are secured by lashing them against the front end of the body. The lashing is threaded through the holes in the ends of the transoms and fastened to the body of the truck. Small parts are placed in bags at the front of the load.

(*f*) *Truck load No. 6 — Footwalk load* (fig. 30). Parts in this load should be lashed down to prevent shifting during transport.

(*g*) *Truck load No. 7 — Grillage load* (fig. 31). Landing mats are

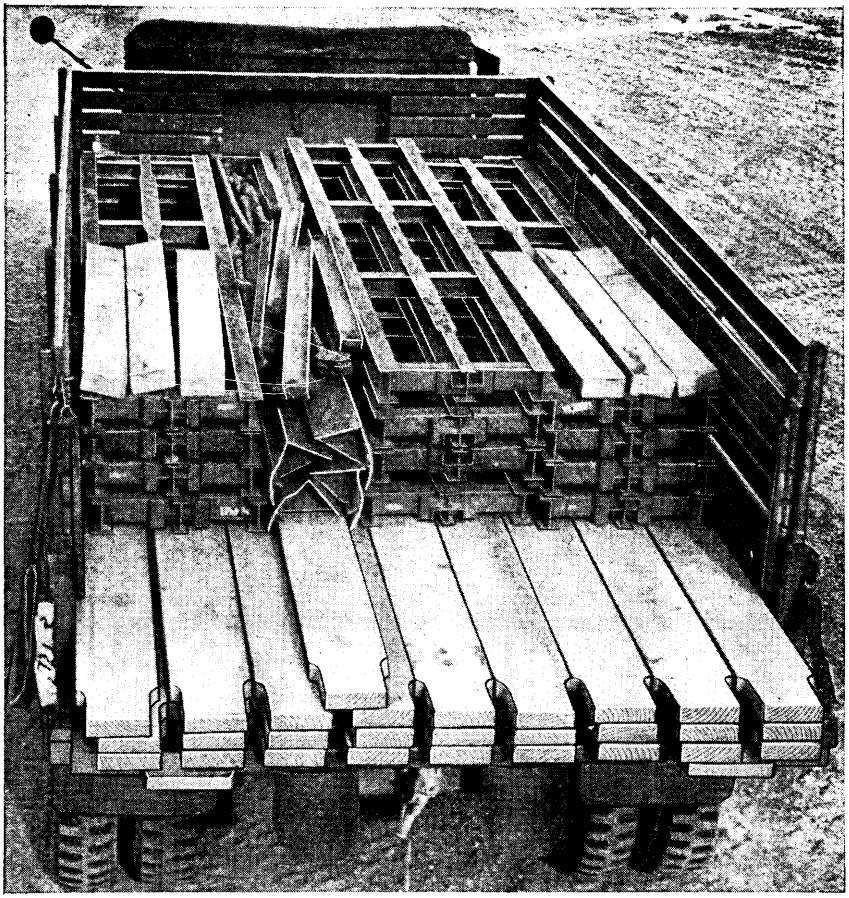


Figure 26. Truck load No. 3—Decking load on 2½-ton LWB truck.

placed in two stacks of 15 panels each. Care must be taken in loading to keep the mats against the front of the body or the tailgate cannot be closed. Grillage timbers are stacked on the mats and the load lashed down to prevent shifting.

(*h*) *Truck load No. 7-1 — Supplemental grillage load* (fig. 32). Grillage is loaded flat on the floor of the truck and two stacks of landing mats placed on them. Rams are placed on top of the mats and the whole load lashed down to prevent shifting.

(*i*) *Truck load No. 8 — Overhead-bracing load* (fig. 33). Three rows of overhead-bracing supports, four each, are placed on the floor of the truck. Two rows of four each are then placed in an inverted position between the bottom three rows. Bracing frames and bags of bolts are placed on the floor at the rear of the truck and sway braces are placed along each side of the load.

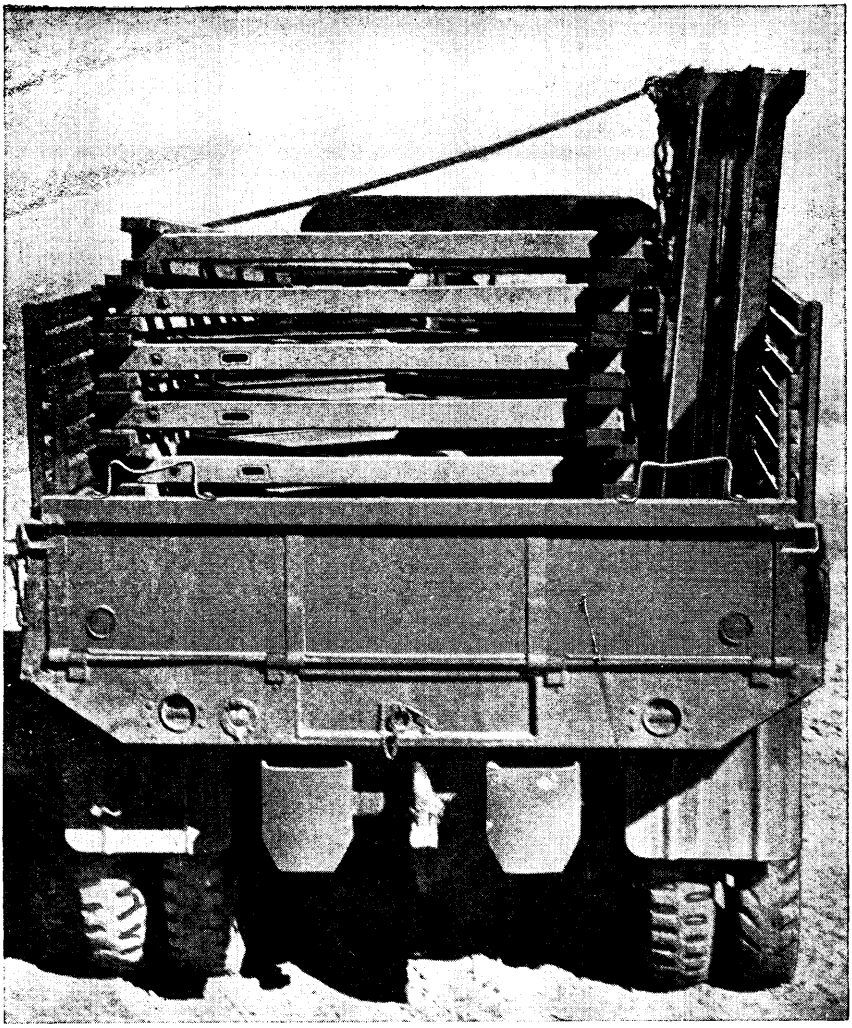


Figure 27. Truck load No. 4—Panel load on 2½-ton LWB truck.

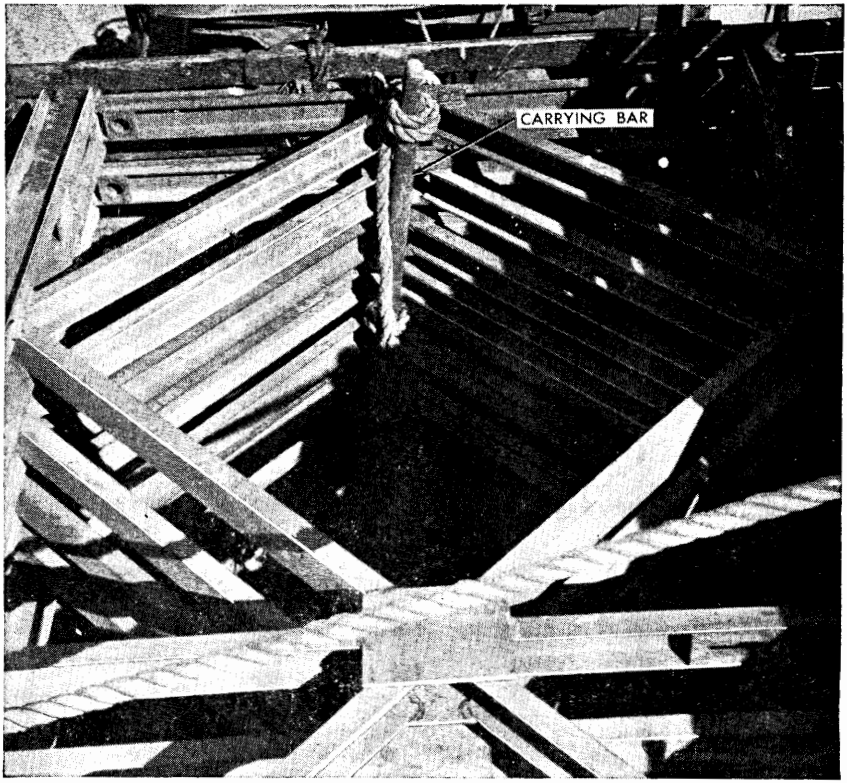


Figure 28. Use of carrying bar to anchor panels in panel load.

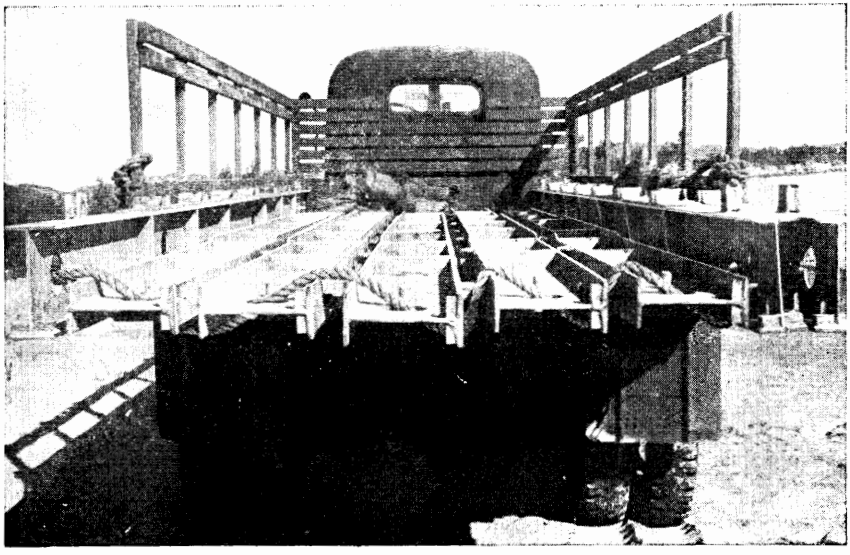


Figure 29. Truck load No. 5—Transom load on 2½-ton COE truck.

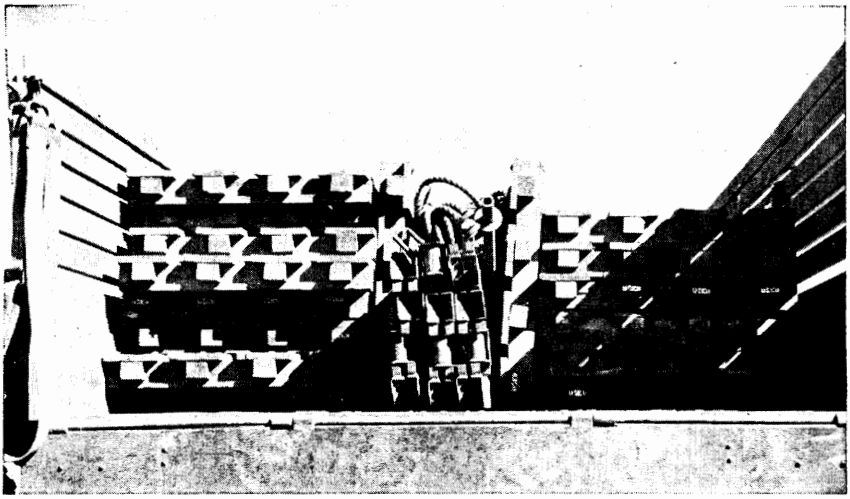


Figure 30. Truck load No. 6—Footwalk load on 2½-ton LWB truck.

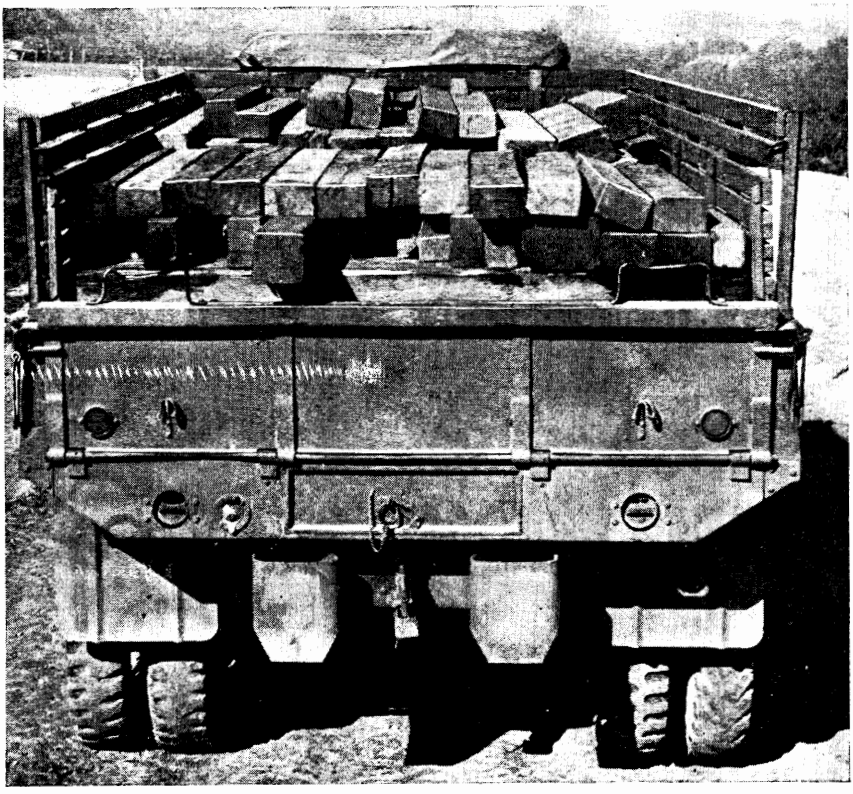


Figure 31. Truck load No. 7—Grillage load on 2½-ton LWB truck.

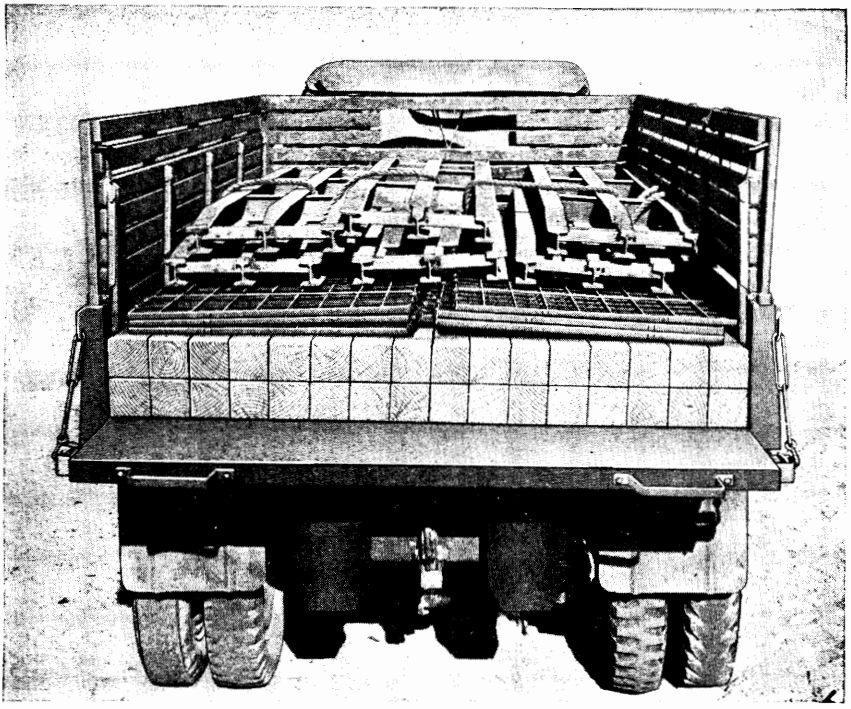


Figure 32. Truck load No. 7A—Supplemental grillage load on 2½-ton LWB truck.

61. Expedient Truck Loads

a. GENERAL. As an expedient, one basic bridge set minus depot spares can be carried on sixteen 2½-ton LWB trucks and thirteen 2½-ton bolster trucks and trailers of the engineer ponton bridge company, rigid boat (T/O & E 5–297). Decking, panel, and transom loads are carried on the bolster trucks and trailers; other loads, on the 2½-ton LWB trucks. The loads on the 2½-ton trucks are the same as the standard loads for the panel bridge company. The loads on the bolster trucks and trailers as as follows:

Trailer load No. 4A—Panel load.
Trailer load No. 5A—Transom-decking load.
Trailer load No. 5B—Transom load.

Trailer load No. 4A, panel load, carries the equipment in two truck loads No. 4, panel load. Trailer load No. 5A, transom-decking load, carries the equipment in one truck load No. 3, decking load, plus one truck load No. 5, transom load. Trailer load No. 5B carries the equipment in two truck loads No. 5, transom load. Table 25 gives the number of truck and trailer loads from the rigid boat company that are required to build each type and size of bridge.

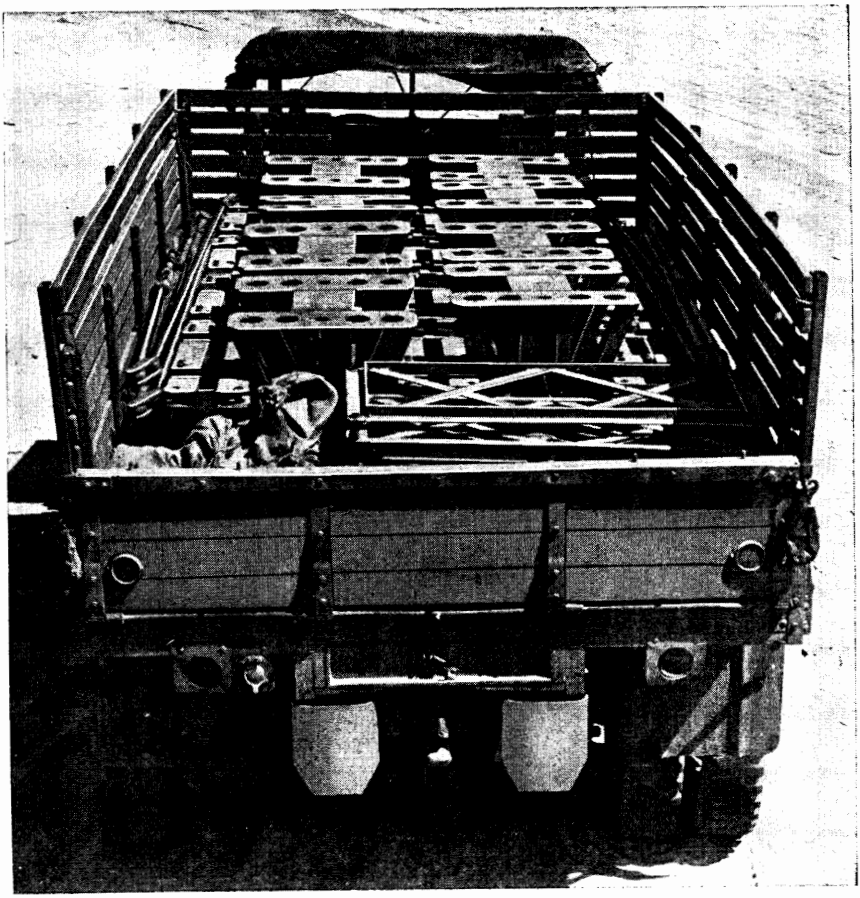


Figure 33. Truck load No. 8—Overhead-bracing load on 2½-ton LWB truck.

Table 25. Number of truck and trailer loads required to build different spans of panel bridge, Bailey type, M2, with Nose, Using Transportation of Rigid Boat Company

Bridge		Number of unit truck loads									Total number of vehicles		Number of bridges that can be built using transportation of rigid boat company	
Span (ft.)	Type	Accessory	Ramp	Decking	Panel		Transom-Decking	Footwalk	Grillage[1]		Overhead bracing			One bridge platoon	Two bridge platoon (one company)
		2½ ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton bolster trk w/tlr	2½-ton bolster trk w/tlr	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trucks	2½-ton bolster truck w/tlr	11 2½-ton trks 21 2½-ton bolster trks w/tlrs	22 2½-ton trks 42 2½-ton bolster trks w/tlrs
		Load No. 1	Load No. 2	Load No. 3	Load No. 4	Load No. 4A	Load No. 5A	Load No. 6	Load No. 7	Load No. 7A	Load No. 8				
30	SS	1	4			1	2	1	1			7	3	1	3
40	SS	1	4			1	2	1	1			7	3	1	3
50	SS	1	4	1		1	2	1	1			8	3	1	2
	DS	1	4	1	1	1	2	1		3		11	3	1	2
60	SS	1	4		1	1	3	1	1			8	4	1	2
	DS	1	4			2	3	1		3		9	5	1	2
70	SS	1	4	1	1	1	3	1	1			9	4	1	2
	DS	1	4	1	1	2	3	1	1			9	5	1	2
80	SS	1	4	1	1	1	3	1	1			9	4	1	2
	DS	1	4	1	1	2	3	1	1			9	5	1	2
	TS	2	4	1	1	3	3	1		3		12	6		1
90	SS	1	4	1		2	4	2	1			9	6	1	2
	DS	1	4	1		3	4	2	1			9	7	1	2
	TS	2	4	1		4	4	2		3		12	8		1

Table 25. Number of truck and trailer loads required to build different spans of panel bridge, Bailey type, M2, with Nose, Using Transportation of Rigid Boat Company—Continued

Bridge		Number of unit truck loads										Total number vehicles		Number of bridges can be built using transportation of rigid boat company	
Span (ft.)	Type	Accessory	Ramp	Decking	Panel		Transom-Decking	Footwalk	Grillage[1]		Overhead bracing			One bridge platoon	Two bridge platoon (one company)
		2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton bolster trk w. tlr	2½-ton bolster trk w. tlr	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trk	2½-ton trucks	2½-ton bolster truck w. tlr	11 2½-ton trks 21 2½-ton bolster trks w. tlrs	22 2½-ton trks 42 2½-ton bolster trks w. tlrs
		Load No. 1	Load No. 2	Load No. 3	Load No. 4	Load No. 4A	Load No. 5A	Load No. 6	Load No. 7	Load No. 7A	Load No. 8				
100	SS	1	4	1		2	4	2	1			9	6	1	2
	DS	1	4	1		3	4	2	1			9	7	1	2
	TS	2	4	1	1	4	4	2	1			11	8	1	2
	DD	2	4	1	1	5	4	2		3		13	9		1
110	DS	1	4	2	1	3	4	2	1			11	7	1	2
	TS	2	4	2		5	4	2	1			11	9	1	2
	DD	2	4	2		6	4	2		3		13	10		1
	TD	2	4	2	1	8	4	2		3		14	12		1
120	DS	1	4	1		4	5	2	1			9	9	1	2
	TS	2	4	1		5	5	2	1			10	10	1	2
	DD	2	4	1	1	6	5	2		3		13	11		1
	TD	2	4	1	1	9	5	2		3		13	14		1
130	DS	1	4	2		4	5	2	1			10	9	1	2
	TS	2	4	2	1	5	5	2	1			12	10		1
	DD	2	4	2		7	5	2	2			12	12		1
	TD	2	4	2	1	10	5	2		3		14	15		1
	DT	2	4		1	10	7	2	[2]		2	11	17	1	2
140	DS	1	4	2	1	4	5	2	1			11	9	1	2
	TS	2	4	2		6	5	2	2			12	11		1

	DD	2	4	2		8	5	2	2			12	13		1
	TD	2	4	2		11	5	2		3		13	16		1
	DT	2	4			11	7	2		3	2	13	18		1
150	TS	2	4	2	1	6	6	2	1			12	12		1
	DD	2	4	2	1	8	6	2		3		14	14		1
	TD	2	4	2		12	6	2		3		13	18		1
	DT	2	4	1		12	7	2		3	2	15	19		1
160	TS	2	4	2		7	6	2	1			11	13	1	2
	DD	3	4	2		9	6	2	2			13	15		1
	TD	3	4	2	1	12	6	2		3		15	18		1
	DT	2	4			13	8	2	[2]		2	10	21	1	2
	TT	3	4			18	8	2	[2]		2	14	26		1
170	DD	3	4	3	1	9	6	3		3		17	15		1
	TD	3	4	3	1	13	6	3		3		17	19		1
	DT	2	4	1	1	13	8	3	[2]		2	13	21		1
	TT	3	4	1		19	8	3	[2]		2	13	27		1
180	DD	3	4	3		10	6	3	2			15	16		1
	TD	3	4	3		14	6	3		3		16	20		1
	DT	3	4			14	9	3	[2]		2	12	23		1
	TT	3	4			21	9	3	[2]		2	12	30		1
190	TD	3	4	3		15	7	3		3		16	22		1
	DT	3	4	1		15	9	3		3	2	16	24		1
	TT	3	4			22	10	3	[2]		2	12	32		1
200	DT	3	4	1		15	9	3		3	2	16	24		1
	TT	3	4			24	10	3	[2]			12	34		1
210	DT	3	4	2	1	15	9	3		3	2	18	24		1
	TT	3	4			26	11	3	[2]		2	12	37		1

[1] Grillage requirements based on soil with a safe bearing pressure of 2 tons per square foot.

[2] Grillage supplied will not support these bridges and must be improvised in the field (see chapter 10).

Load conversion equations

Load on 2½-ton bolster trk w/tlr		Equivalent loads on 2½-ton trk		2½-ton COE trk
1 Panel (No. 4A)	=	2 Panel (No. 4)		
1 Transom-Decking (No. 5A)	=	1 Decking (No. 3)	+	1 Transom (No. 5)
1 Transom (No. 5B)	=			2 Transom (No. 5)

b. Loading Individual Bolster Trucks and Trailers. Small parts for these loads are placed in the boxes on the bolster truck as indicated in table 26.

Table 26. Loading Small Parts of Panel and Transom Loads in Boxes and on Deck of Bolster Truck

Part	Equipment box	Right box	Left box	Deck
		Panel load (No. 4A)		
Bag, transport	..	3	4	..
Bar, carrying	4	..	..	..
Bolt, bracing	..	70	..	..
Bolt, chord	..	..	30	..
Frame, bracing	..	..	..	8
Hammer, hide-faced	4	..	..	..
Lashing	..	..	4	..
Pin, panel	60	..	..	..
Pin, safety	60	..	..	..
Plate, tie	..	6	..	..
Wrench, socket, 1⅛"	4	..	..	..
Wrench, structural, 1⅛"	4	..	..	..
Wrench, structural, 1⅜"	4	..	..	..
		Transom-decking load (No. 5A)		
Bag, transport	..	7	6	..
Bar, carrying	2	..	..	..
Bolt, bracing	..	20	..	..
Bolt, riband	..	..	18	..
Clamp, transom	..	30	20	..
Lashing	2	..	..	..
Raker	..	..	..	8
Wrench, structural, 1⅛"	2	..	..	..
Wrench, structural, 1½"	2	..	..	..
		Transom load (No. 5B)		
Bag, transport	..	..	4	..
Bar, carrying	4	..	..	..
Clamp, transom	60	..	..	..
Lashing	..	..	4	..

(1) *Trailer load No. 4A — Panel load* (fig. 34). The towing connection between the truck and trailer is made by using two M4 deck balk with end lugs engaged in the bolster slots. The balk must be securely lashed to the bolsters independent of the load. The panels are pinned together in pairs and laid flat on these balk. Panels are staggered to provide clearance for the panel pins. A crane should be used to load and unload panels. The load is secured with load binders.

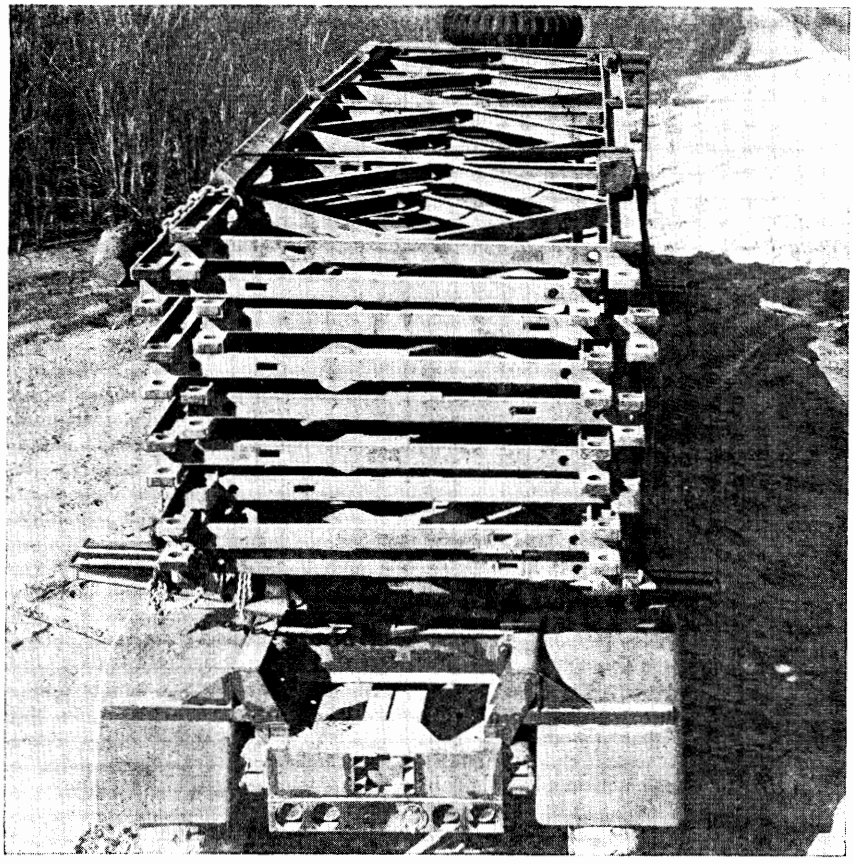


Figure 34. Trailer load No. 4A—Panel load on 2½-ton bolster truck and trailer.

(2) *Trailer load No. 5A — Transom-decking load* (fig. 35). The towing connection between the truck and trailer is made by placing two transoms on each side of the load with their raker lugs engaging the front of the truck bolster and the rear of the trailer bolster. The remaining four transoms are laid flat to form a deck for the rest of the load. A tight double wrap of heavy chain both forward and back of each bolster is necessary to fasten the transoms to the bolsters securely and to prevent raker lugs from rising and disengaging (fig. 36). Care must be taken so the chains are not pinched between the sharp edges of the transoms. Bolster chocks are moved inward to compact the load and reduce lateral movement of transoms. Stability can be improved by placing wedge-shaped wooden blocks under the trailer bolster to reduce rocking action (fig. 36). Loading is best accomplished by removing two bolster chocks and loading over the side. Chess are

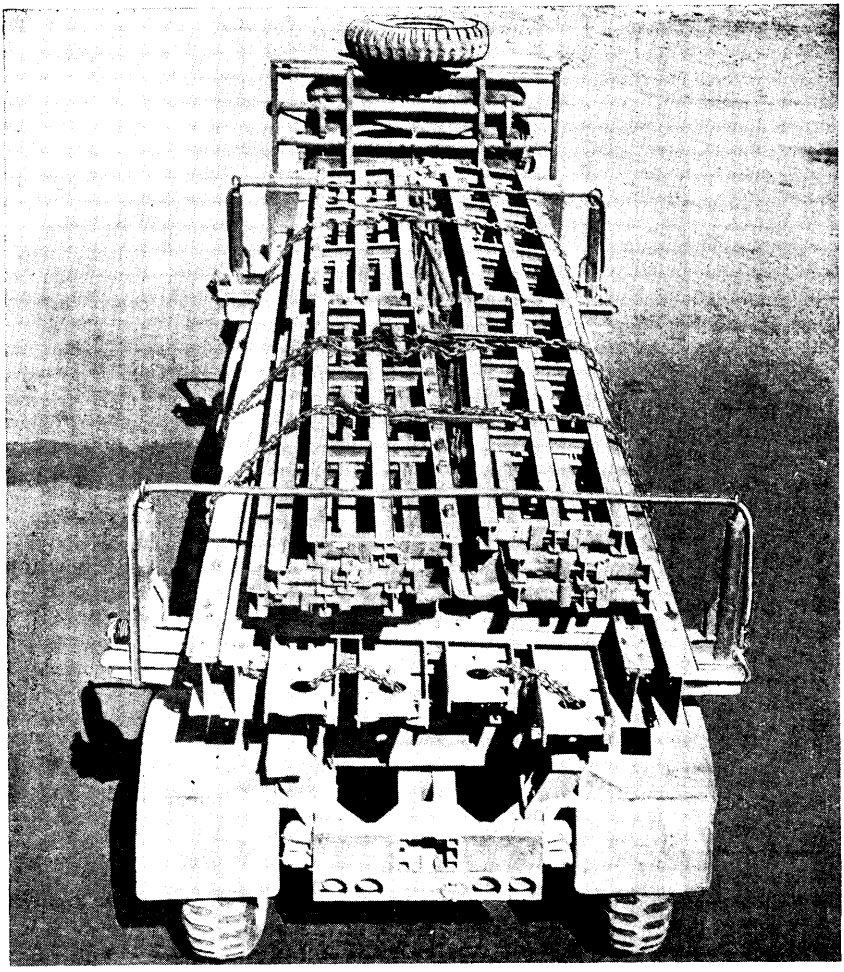


Figure 35. Trailer load No. 5A—Transom-decking load on 2½-ton bolster truck and trailer.

laid on the bed formed by the transoms and stringers are placed next. Packing timbers are used to support the overhanging ends of the rear row of stringers. Guardrail ribands and sway braces are packed between the stacked stringers. Rakers are carried on the deck of the truck and small parts in the truck boxes. Three heavy chains tightened with chain binders are used to secure the load.

(3) *Trailer load No. 5B — Transom load* (fig. 37). The towing connection is made the same as for load 5A. The rest of the transoms are secured to the load with three chains tightened with chain binders.

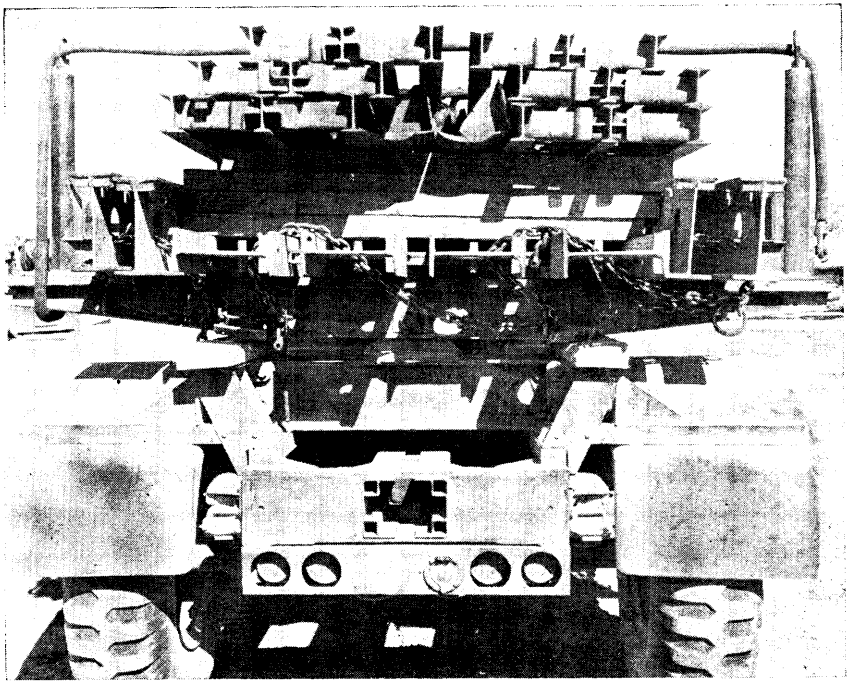


Figure 36. Transoms used for towing connection between bolster truck and trailer securely wrapped with heavy chain to prevent raker lugs from disengaging bolsters. Note wedge-shaped wood blocks beneath trailer bolster to increase stability of load.

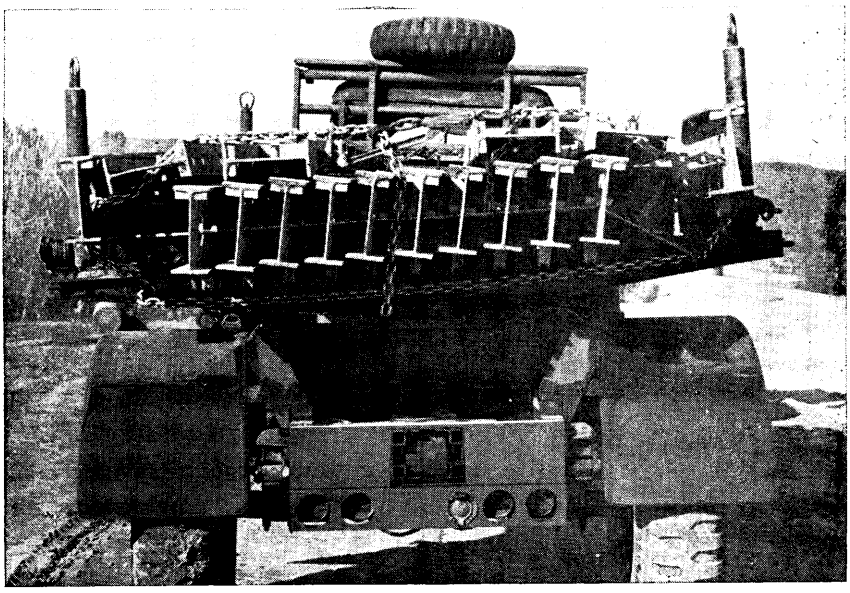


Figure 37. Trailer load No. 5B—Transom load on 2½-ton bolster truck and trailer.

62. Stocking and Storage

a. Oversea Shipment Depots. Oversea shipment depots in the zone of interior store panel-bridge equipment by sets (tables 10 and 11) or by parts, depending on the amount of storage space available. Storage by sets increases accuracy and speed on filling requisitions and in shipping. Storage by parts requires the least amount of storage space but increases the time required for loading.

b. Rear-area Depots in Theaters. Panel-bridge equipment received by rear-area depots in theaters is normally stored by parts.

c. Army and Forward Bridge Dumps. Parts in army and forward bridge dumps are normally stored by parts or by truck loads, depending on the number of bridge sets carried in stock, location of the dump, and rate of movement of the equipment. Dumps with three to four bridge sets in stock normally store parts by truck loads (tables 12 to 21). This method uses the most storage space but requires less time for loading.

63. Transportation to Bridge Site

a. Panel Bridge Company (T/O & E 5–287). The panel bridge company is organized to transport panel bridge equipment between depot or dump and bridge site. When not engaged in transport work, it helps maintain parts in the depot (par. 64).

(1) *Organization and equipment.* The company has two bridge platoons and one headquarters platoon. For carrying bridge equipment, each platoon has seventeen 2½-ton trucks and three 2½-ton COE trucks (for transom loads). Headquarters platoon has six 2½-ton trucks (for four panel and two crib-pier loads) and two 2½-ton COE trucks (for transom loads).

(2) *Capability.* Table 23 lists the number of bridges that can be transported by the platoons of a panel-bridge company.

b. Rigid Boat Company. (T/O & E 5–297.) Vehicles of the rigid boat company normally transport the M4 floating bridge. However, they can also be used as an expedient to transport panel-bridge equipment.

(1) *Organization and equipment.* Each bridge platoon of the rigid boat company has eleven 2½-ton LWB trucks and twenty-one 2½-ton bolster trucks and trailers.

(2) *Capability.* Vehicles in one bridge platoon can carry nearly all types and lengths of bridge up to 140 feet. Vehicle requirements for various bridges are given in table 25.

c. Bridge Trains. The bridge train to fit the span, type, and capacity of bridge desired is planned in advance to save time and eliminate

errors in dispatching equipment to the bridge site. Table 27 gives suggested order of dispatch of standard truck loads for various spans and types of construction.

64. Maintenance

a. DEPOT. Depots inspect and check panel-bridge parts in stock for completeness and serviceability. All equipment is cleaned and greased, and damaged or bent parts are repaired, straightened, or replaced. A special check is made of parts returned from dismantled bridges for reissue. Lost or damaged parts in standard truck loads are replaced from depot spares.

b. PANEL BRIDGE COMPANY. Bridge parts and erection equipment drawn from depot by the panel bridge company are inspected by the company before delivery to the building unit. Each driver should have a card listing equipment in his load. He should be held responsible for the completeness and serviceability of the load. Damaged or bent parts are returned to depot for replacement. Panel pins, rollers, and other friction surfaces are cleaned and greased when necessary. When not otherwise engaged, the panel bridge company aids the depot in maintaining parts.

c. MAINTENANCE SPARES. Bridge parts and tools not needed for maintenance spares must be returned immediately to depot for reissue.

(1) *Forward areas.* Bridges in forward areas are normally maintained by the bridge guards. Suggested maintenance spares to be left at bridge sites for these guards are listed below. Other parts may be kept on hand when the tactical situation makes it necessary.

(*a*) Wrench, ratchet (for double-story bridges only) 1
(*b*) Wrench, socket, 1-inch 2
(*c*) Wrench, structural, 1⅛-inch 2
(*d*) Wrench, structural, 1½-inch 2
(*e*) Wrench, structural, 1⅞-inch 1
(*f*) Chess 13
(*g*) Riband, guardrail 4
(*h*) Bolts, riband, guardrail 6

(2) *Rear areas.* Bridges in rear areas are maintained by parties that move from bridge to bridge. As these parties carry their own tools, no tools need be left at bridge sites.

65. Use of Master Tables

The following examples show how to use the master tables for determining equipment and transportation requirements and the order of dispatch of loads from depot.

a. One 100-foot DD Bridge. Loads required using transportation of panel bridge company (master table 23):

	2½-ton truck
Load No. 1 (table 12)	2
Load No. 2 (table 13)	4
Load No. 3 (table 14)	5
Load No. 4 (table 15)	11
Load No. 5 (table 16)	4
Load No. 6 (table 17)	2
Load No. 7A (table 19)	3
Total	31

These trucks are available in two panel bridge platoons (table 23). Table 27 shows a suggested order in which to dispatch these loads from depot to bridge site.

b. Two 70-foot DS Spans and 21-foot 7-inch DD (2V–2V) Panel Crib Pier. Loads required using transportation of panel bridge company:

(1) Two 70-foot DS spans (master table 23), (only half the number of ramp and grillage loads are needed because the span junction over the pier does not have ramp or grillage):

	2½-ton truck
Load No. 1 (table 12)	2
Load No. 2 (table 13)	4
Load No. 3 (table 14)	8
Load No. 4 (table 15)	10
Load No. 5 (table 16)	6
Load No. 6 (table 17)	1
Load No. 7 (table 18)	1
Total	32

(2) Pier (master table 24):

	2½-ton truck
Load No. 1 (table 12)	(1)*
Load No. 4 (table 15)	2
Load No. 5 (table 16)	1
Load No. 9 (table 21)	2
Total	5

* Use equipment from accessory load for bridge.

(3) These trucks are available in *one* panel bridge company.

CHAPTER 7

RECONNAISSANCE AND PRELIMINARY PLANNING

66. General

Each available bridge site must be reconnoitered to select the site which is most economical in use of available personnel, equipment, and construction time. The reconnaissance at each site is used to determine the most suitable type of bridge to be used, to determine the method of construction, and to aid in making the construction plans. For a general discussion of engineer reconnaissance, see FM 5–6.

67. Requirements

The reconnaissance officer should be given the following information before making his reconnaissance:

a. General Area in Which Bridge is Needed. The general location of the bridge is determined by tactical requirements of the advance.

b. Strength of Bridge Needed. The strength of the bridge is determined by type of vehicles it must carry.

c. Length of Service Intended for Bridge. A light bridge may suffice temporarily for emergency crossings; but for longtime use the bridge may have to be reinforced at a later date for heavier vehicles.

d. Time Allowed for Bridge Construction. The time allowed for constructing the bridge is determined by tactical requirements. As manpower and materials are often critical, the engineer should economize on these items wherever the tactical situation permits.

68. Preliminary Studies

A thorough evaluation of information from preliminary studies may aid the reconnaissance by limiting it to a few suitable sites. Sources of preliminary information are intelligence reports, interviews with natives, and special studies on bridges and other features along the river; maps; aerial photographs (including stereo-pairs), and personal aerial reconnaissance (see ch. 6, FM 20–100).

69. Reconnaissance

a. Methods. If possible, a ground reconnaissance is made. When ground reconnaissance is impossible because of enemy action, an aerial reconnaissance is made. The aerial photographs are taken from low

altitude so the gap can be scaled off and an accurate estimate made of the river banks, demolished piers, abutments, and the like.

b. SITE REQUIREMENTS. The following site requirements are desirable for a panel bridge:

(1) Road over which bridge equipment can be moved to bridge site.

(2) Approaches requiring little preparation.

(3) Access roads at each end of the bridge tying in to main road net. These roads should not require excessive maintenance.

(4) Firm and stable banks.

(5) Banks of about equal height.

(6) Cleared space large enough for assembly of bridge and wide enough for unloading and stacking the parts and erection tools. The approach road often affords such space.

(7) An area suitable for a motor park affording cover and concealment, if required.

(8) Surrounding terrain affording natural protection for security details.

c. REPORT. The reconnaissance report contains a description of every usable site reconnoitered with a recommendation as to the preferred site. The report includes:

(1) Location of site.

(2) Span, construction, and capacity of bridge that could be built at site.

(3) Width of gap.

(4) Slope of banks.

(5) Condition of banks and capacity of abutments.

(6) Proposed location of rocking rollers, plain rollers, and base plates.

(7) Site preparation necessary.

(8) Suggested method of transporting men and equipment to far bank.

(9) Sketch showing profile of extension of center line of bridge extending 100 feet on near shore and 50 feet on far shore.

(10) Sketch showing lay-out of materials, building site, turn-around, and dispersal area for trucks before and after unloading.

(11) Location and lay-out of assembly area for bridge equipment before transportation up to site, including dispersal area for trucks at assembly area.

(12) Truck route to bridge site from equipment dump or assembly point.

(13) Proposed plan for posting of security details (for tactical bridges only).

d. REFERENCE. For general discussion of reconnaissance for new bridge construction, see FM 5-10.

70. Planning

A well-organized plan is important to insure speedy economical use of equipment and manpower on the bridge construction. Some of the factors to be considered in the plan are—

a. Site Selection. A very careful selection of bridge site from the reconnaissance reports is important. Consideration must be given the amount of work required on the approaches, abutments, and piers, as this work usually takes up the greatest percentage of the over-all bridge construction time.

b. Span and Grillage. Before determining the span required, the location of the rocking rollers must be determined as described in chapter 9. Since the bridge bearings must be at least 2 feet 6 inches behind the rollers, the bridge span will be at least 5 feet longer than the span between rollers. An estimate must be made of the bearing capacity of the abutments and grillage selected to carry the base plate and roller loads. In designing the grillage under the base plates, the possibility of the bridges being reinforced later to carry heavier loads must be considered.

c. Construction Sequence. The construction consists of the following procedures:

(1) Preliminary site preparation (clearing of mines, removing obstacles, leveling construction area, and constructing turn-around for trucks).

(2) Abutment preparation (excavating and leveling of abutment surface).

(3) Roller lay-out and leveling (including construction of grillage).

(4) Transporting and unloading of equipment.

(5) Bridge assembly and launching.

(6) Jacking bridge down and constructing ramps.

(7) "Finishing" bridge (laying wear treads, constructing panel guards or hubguards, posting bridge, placing guard posts and luminous markers when required, and posting signs on approach road).

d. Personnel and Equipment. The number of men required for the bridge construction is estimated, working parties are set up, and each given specific duties. This organization for normal bridges is given in chapter 8. Extra men and equipment, such as bulldozers and cranes, will be needed for special methods of launching, building piers, and preparing site and traffic turn-arounds.

e. Construction Time. The estimate of time must be carefully made and should include time for each of the procedures listed in *c* above. Time needed for each operation is determined by the equipment and personnel available. Time needed for assembling and launching a normal bridge is given in chapter 8.

f. Transportation of Equipment. Proper planning of the movement of the bridge trucks is important to provide the bridge equipment

without confusion when it is needed. If the equipment is to be stacked at the site, the transportation is timed to arrive when the stacking site is ready and before the bridge assembly is to begin. If the bridge is to be built from the trucks, using a truck train as described in chapter 6, a careful plan is made of the sequence in which the vehicles are needed and the timing of their movements so there will be little waiting to unload. Chapter 6 lists the order in which the trucks of the truck train are needed for various bridges. The plan must also consider the time necessary for the trucks to travel from the bridge dump to the bridge site. If the bridge dump is too far back, the loaded trucks may be assembled at an assembly site nearer the bridge and dispatched from there.

CHAPTER 8

WORKING PARTIES AND TIMES

71. Scope

This chapter describes the organization of the working details and the construction time for the bridge assembly. The organization of the lay-out and abutment preparation details is described in chapter 9.

72. Organization of Working Parties

a. SUPERVISION. An officer supervises all construction operations. For single-story bridges over 100 feet long, or double- or triple-story bridges, an additional officer is necessary. A senior noncommissioned officer assists in supervision.

b. WORKING DETAILS. If equipment must be unloaded from trucks, the working party is divided into construction and unloading details, the latter under a senior noncommissioned officer who also dispatches empty trucks to the motor park.

(1) The organization of construction details is given in table 28. It does not provide for launching the bridge. When the bridge is to be pushed forward, all other work stops and the entire working party launches it. If the bridge is too heavy to be pushed across by manpower, a truck or bulldozer should be used.

(*a*) Normally, the construction details can start work as soon as the site is prepared without waiting for completion of unloading.

(*b*) Additional men must be provided for construction of approaches, traffic control, and security patrols, if these tasks are to be carried on simultaneously with construction of the bridge.

(2) The unloading detail will consist of three to eight 8-man parties depending on the type and length of bridge. (See table 29.)

73. Duties of Construction Details

The duties of the construction details are as follows:

a. PANEL DETAIL. (1) Carries (fig. 38), places, and pins together panels in launching nose and bridge.

(2) As soon as all panels are in place, divides into two crews. One crew crosses to far bank and begins dismantling launching nose. The other carries necessary parts to far bank for completion of end of bridge and installation of ramp.

Table 28. Organization of Construction Details

Detail	NUMBER OF NCOs AND EM								
	Type of bridge								
	Single-single	Double-single	Triple-single	Double-double	Triple-double	Double-triple	Triple-triple	Double-triple	Triple-triple
	Construction by manpower only							Using one crane*	
CRANE	.....	.....	.....	.....	.....	.....	.....	0–3	0–3
Truck driver	.....	.....	.....	.....	.....	.....	.....	(1)	(1)
Crane operator	.....	.....	.....	.....	.....	.....	.....	(1)	(1)
Hook man	.....	.....	.....	.....	.....	.....	.....	(1)	(1)
PANEL	1–14	1–14	2–28	2–32	3–50	3–50	3–68	3–30	3–30
Carrying	(12)	(12)	(24)	(28)	(44)	(44)	(60)	(24)	(24)
Pin	(2)	(2)	(4)	(4)	(6)	(6)	(8)	(6)	(6)
TRANSOM	1–9	1–10	1–10	1–10	1–10	2–28	2–28	2–20	2–20
Carrying	(8)	(8)	(8)	(8)	(8)	(24)	(24)	(16)	(16)
Clamp	(1)	(2)	(2)	(2)	(2)	(4)	(4)	(4)	(4)
BRACING	1–4	1–6	1–8	1–12	1–20	1–32	1–40	1–32	1–38
Sway brace	(2)	(2)	(2)	(2)	(2)	(6)	(6)	(6)	(6)
Raker	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Bracing frame	.....	(2)	(2)	(4)	(4)	(8)	(8)	(10)	(8)
Chord bolt	.....	.....	.....	(4)	(8)	(10)	(14)	(10)	(14)
Tie plate	.....	.....	(2)	.....	(4)	.....	(4)	.....	(4)
Overhead supp't	.....	.....	.....	.....	.....	(6)	(6)	(4)	(4)
DECKING	1–12	1–12	1–12	1–12	1–12	1–12	1–12	1–12	1–12
Stringer	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)
Chess and riband	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
TOTAL	4–39	4–42	5–58	5–66	6–92	7–122	7–148	7–97	7–103

* Normally, a crane is not used for single- or double-story construction.

Table 29. Number of unloading parties needed

Type	Span (feet)	Number of unloading parties[1]
SS	30–60	3
	70–90	4
DS	50–80	4
	90–120	5
TS	70–120	5
	130–140	6
DD	90–150	6
	160–170	7
TD	110–120	6
	130–180	7
	190–200	8
DT	130–170	7
	180–200	8
TT	150–200	8

[1] Each unloading party contains 1 NCO and 8 EM.



Figure 38. Panel detail carrying panel.



Figure 39. Transom detail installing transom in place.

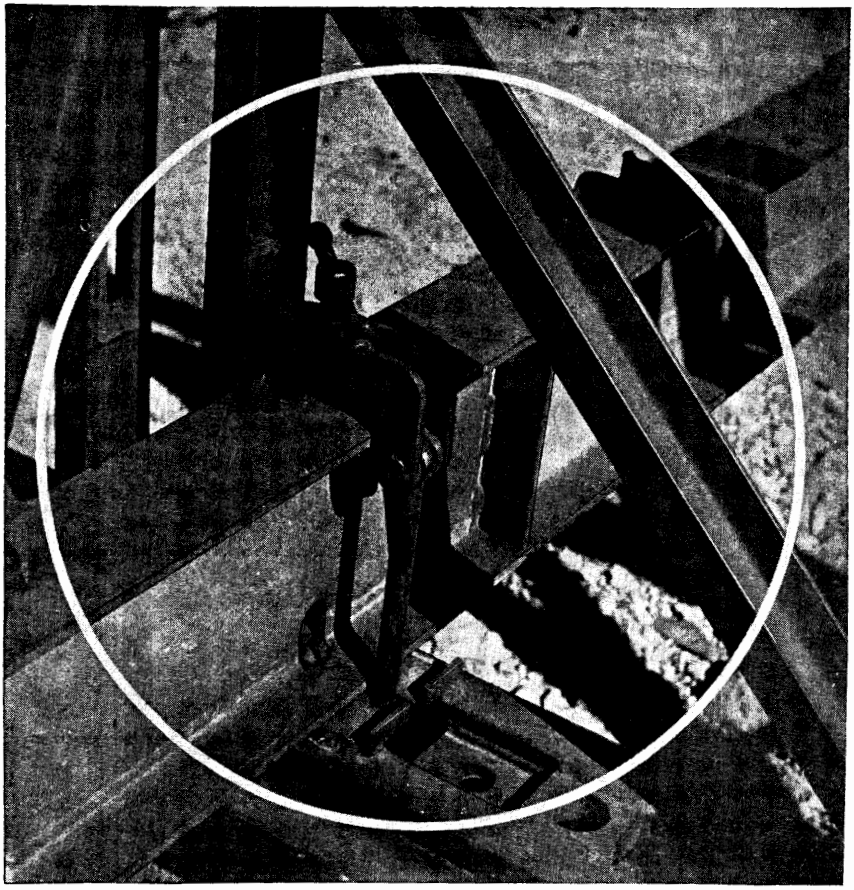


Figure 40. Transom clamp in place.

(3) Reforms as a single detail and completes dismantling of launching nose.

(4) Installs far-bank end posts.

(5) Jacks down far end of bridge.

(6) Installs far-bank ramp, and places its chess and ribands.

b. TRANSOM DETAIL. (1) Carries, places (fig. 39), and clamps down transoms (fig. 40).

(2) Removes plain rollers on near bank.

(3) Installs end posts on near bank.

(4) Assists decking detail in jacking down near end of bridge.

(5) Installs near-bank ramp and assists decking detail in placing chess and ribands on it.

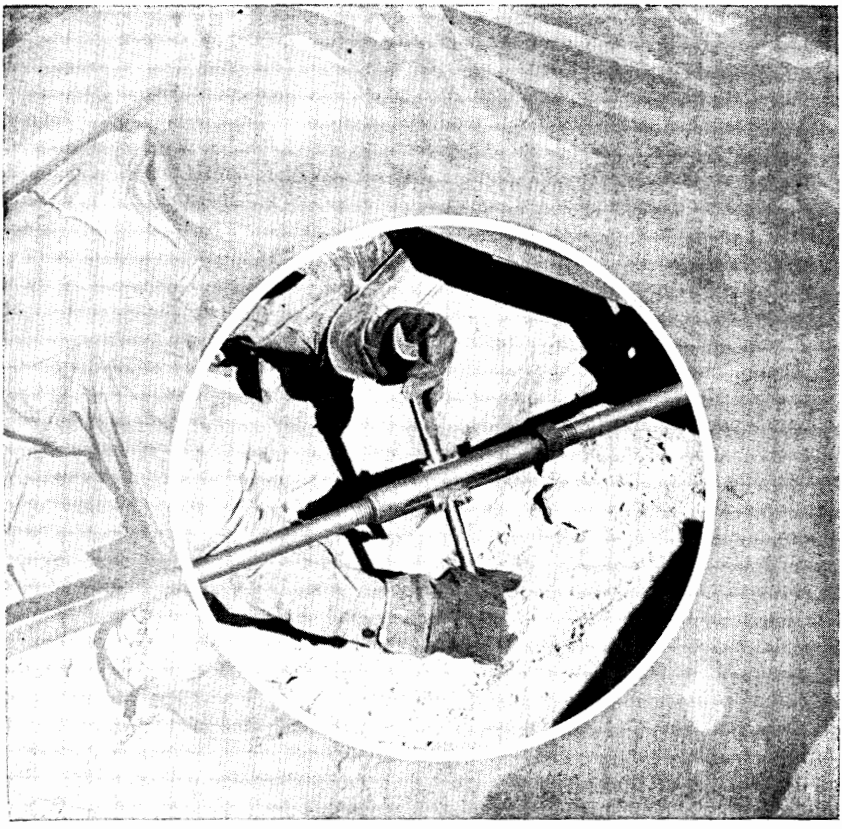


Figure 41. Sway brace being tightened.

c. BRACING DETAIL. Obtains, installs, and adjusts the following parts:

(1) Sway braces (fig. 41).

(2) Rakers (fig. 42).

(3) Bracing frames (fig. 43), on double- and triple-truss bridges only.

(4) Chord bolts (fig. 44), on double- and triple-story bridges only.

(5) Tie plates, on triple-truss bridges only.

(6) Overhead bracing supports, on triple-story bridges only.

d. DECKING DETAIL. (1) Assists panel detail in starting construction of launching nose.

(2) Lays stringers, chess, and ribands on bridge (fig. 45).

(3) Jacks down near end of bridge.

(4) Lays chess and ribands on near-bank ramp.

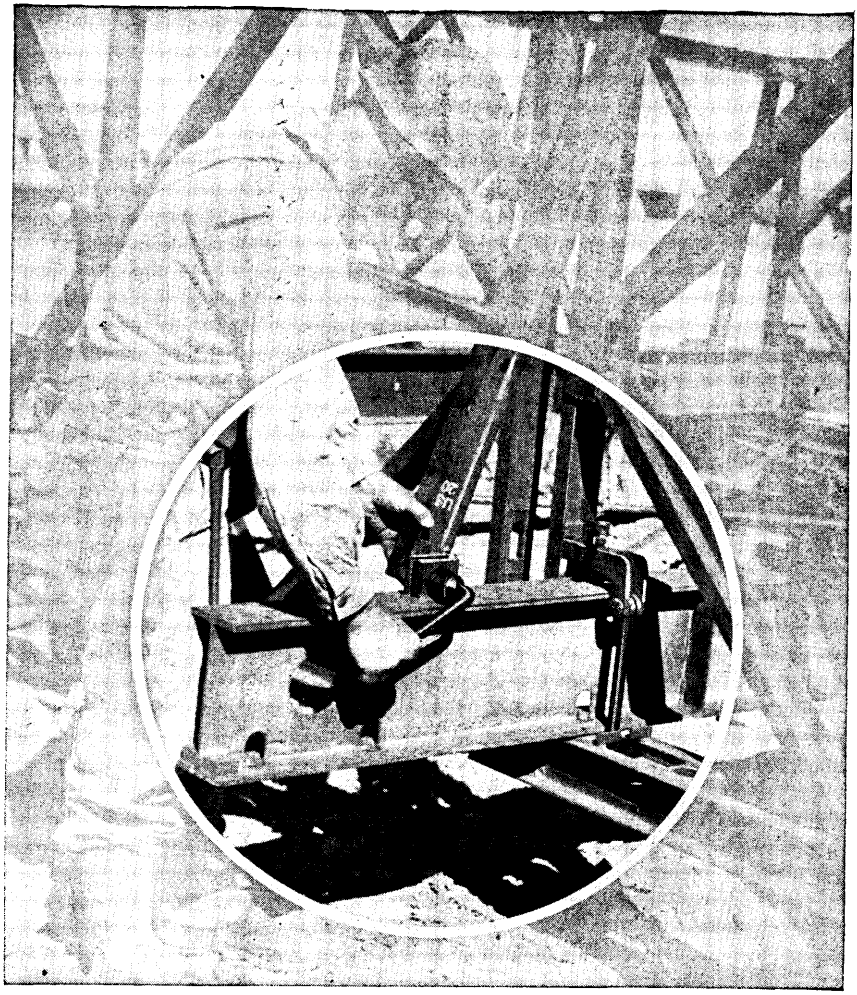


Figure 42. Raker being bolted.

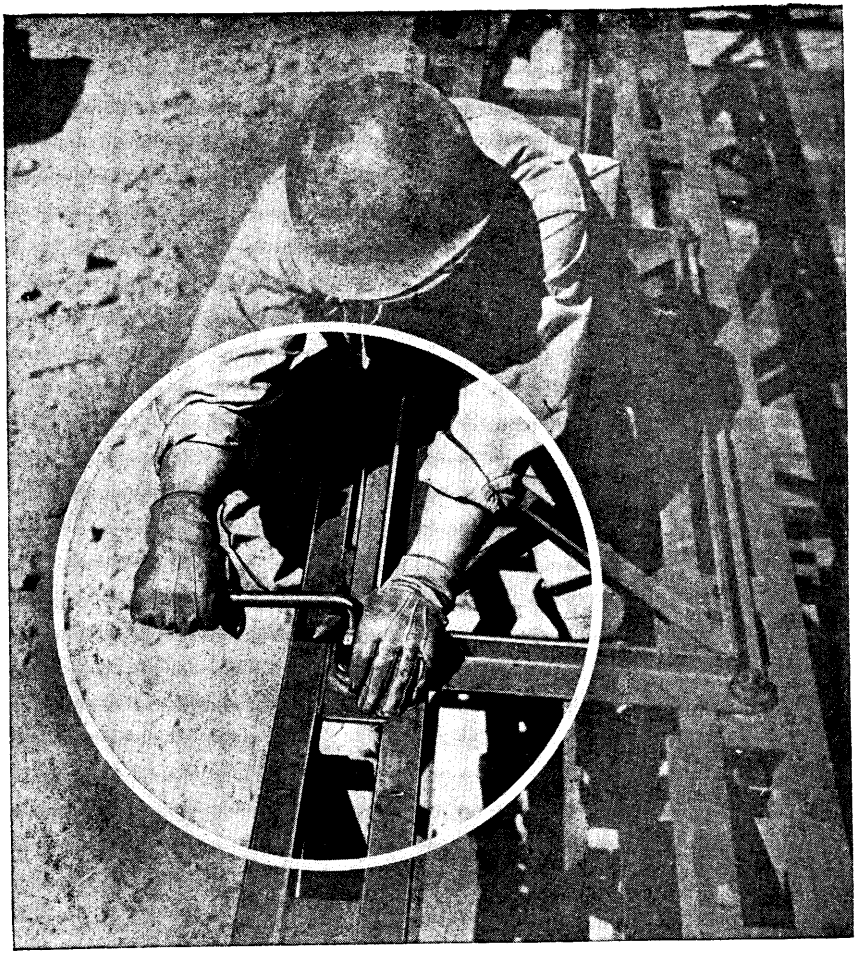


Figure 43. Bracing frame being bolted.

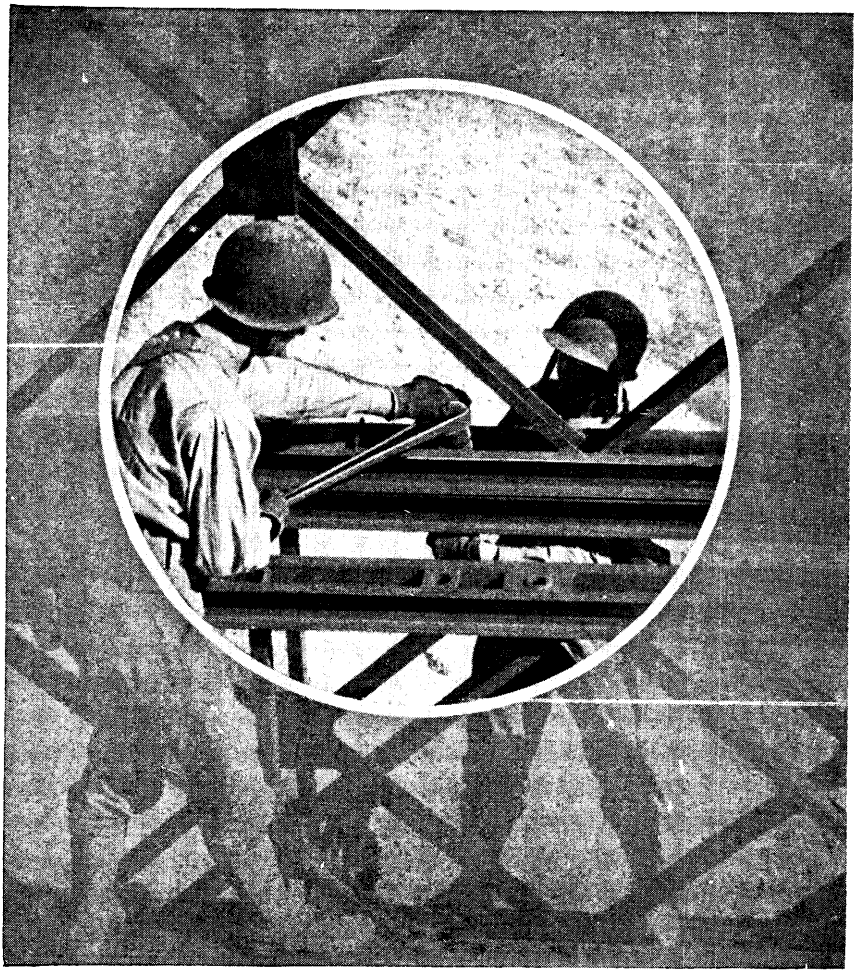


Figure 44. Chord bolt being tightened.

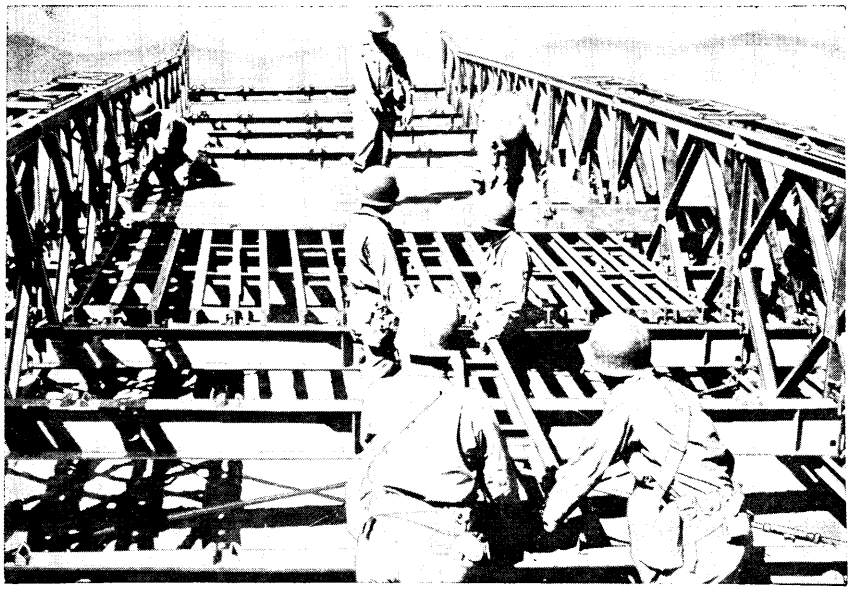


Figure 45. Decking detail laying stringers, chess, and ribands.

c. UNLOADING DETAIL. Unloads trucks as they arrive and stacks parts at bridge site.

74. Times for Various Operations

a. DAYLIGHT CONDITIONS. (1) *Assembly and launching.* Table 30 shows estimated times for daylight assembly and launching of various lengths of different types of bridges when built by manpower alone and when one crane is used. Times do not include preparation of site and lay-out of rollers. These times assume that there is a favorable construction site, that trained personnel are available, that equipment is stacked at site, and that footwalks are omitted. Field conditions, use of untrained troops, poor weather, and enemy activity lengthen construction time. Additional time must also be allowed for addition of wear treads, hub guards, and sign posting.

(2) ROLLER LAYOUT. Add ½ to 4 or more hours for preparation of site, lay-out, and placing of rollers depending upon the amount of work required to level site, construct grillages, and crib up rollers.

(3) *Unloading.* Add ½ hour for unloading from trucks if separate unloading parties are available; if not available, add 1 to 2½ hours according to type of bridge.

b. BLACKOUT CONDITIONS. For blackout conditions, increase daylight times by 50 to 100 percent depending upon light conditions.

Table 30. Estimate of Time for Daylight Construction[1]

Length in feet	TYPE OF BRIDGE								
	Single-single	Double-single	Triple-single	Double-double	Triple-double	Double-triple	Triple-triple	Double-triple	Triple-triple
	Time in hours[2]								
	Construction by manpower only							Using one crane[3]	
40	1½	.....	.....	.....	.....	.....	.....	.....	.....
60	1¾	2	.....	.....	.....	.....	.....	.....	.....
80	2	2½	3	.....	.....	.....	.....	.....	.....
100	2¼	3	3½	4¼	.....	.....	.....	.....	.....
120	.....	3½	4	5	6¾	.....	.....	.....	.....
140	.....	3¾	4½	5¾	7½	11¾	.....	10½	.....
160	.....	.....	5	6¼	8½	13¼	19	11¾	16¼
180	.....	.....	.....	7	9½	14¾	21¼	13¼	18¼
200	.....	.....	.....	.....	.....	16¼	24	14½	20½
	Time in minutes								
Nose (per 10′ bay)	5	7	.....	12	.....	.....	.....	.....	.....
Bridge (per 10′ bay)	7	10	13	17	25	42	60	37	50
Jack down and construct ramps....	40	45	50	55	60	65	65	65	65

[1] These times assume that there is a favorable construction site, that trained personnel are available, that equipment is stacked at site, and that footwalks are omitted. Field conditions, use of untrained troops, poor weather, and enemy activity lengthens construction time. For blackout conditions, increase daylight times by 50 to 100 percent.

[2] Time does not include preparation of site and lay-out of rollers. Preparation of site, lay-out, and placing of rollers will take from ½ to 4 or more hours depending upon amount of work required to level site, construct grillages, and crib up rollers.

[3] Normally, a crane is not used for single- or double-story construction.

CHAPTER 9

LAY-OUT OF SITE AND SUPPLIES

75. General

A bulldozer can be employed to clear out and grade the bridge site and to construct a turn-around. Without a bulldozer, the work can generally be done with squad pioneer tools.

a. TURN-AROUND. A turn-around usually must be constructed to prevent traffic congestion.

b. BRIDGE SITE. The area around the site must be clear and level enough for assembling the bridge and stacking equipment. It should be at least as long as the width of the gap to be spanned, and about 150 feet wide.

c. EQUIPMENT. Details of a suggested lay-out of equipment at bridge site are discussed in paragraphs 76 and 77.

76. Lay-out of Bridge Equipment

The bridge equipment may be either stock-piled at the site or used as it is unloaded from the truck train. See chapter 6 for description of the truck loadings and order of trucks in truck train. If the materials are stock-piled at the site, the stacks are arranged as illustrated in figure 46.

77. Lay-out of Rollers and End Supports

a. ROLLERS. (1) *Rocking rollers.* Rocking rollers are used at both banks during launching. Normally two rocking rollers are used on the near bank for single-truss bridges, and four are used for double- and triple-truss bridges. Two rocking rollers are normally required on the far bank; however, four are used if the skeleton launching nose is double-truss in any part.

(*a*) *Longitudinal spacing.* The rocking rollers are placed far enough from the edge of the gap to be behind the natural angle of repose of the ground (usually about 1½ horizontal to 1 vertical).

(*b*) *Lateral spacing.* Rocking rollers are used under the inner and second truss at each side of the bridge. Normally, rocking-roller templates are used under the rollers to space them under the trusses. The rocking-roller templates are spaced 11 feet 6½ inches apart as illustrated in figure 47. If rocking-roller templates are not used, the bearings under the rocking rollers can be located by using a transom as illustrated

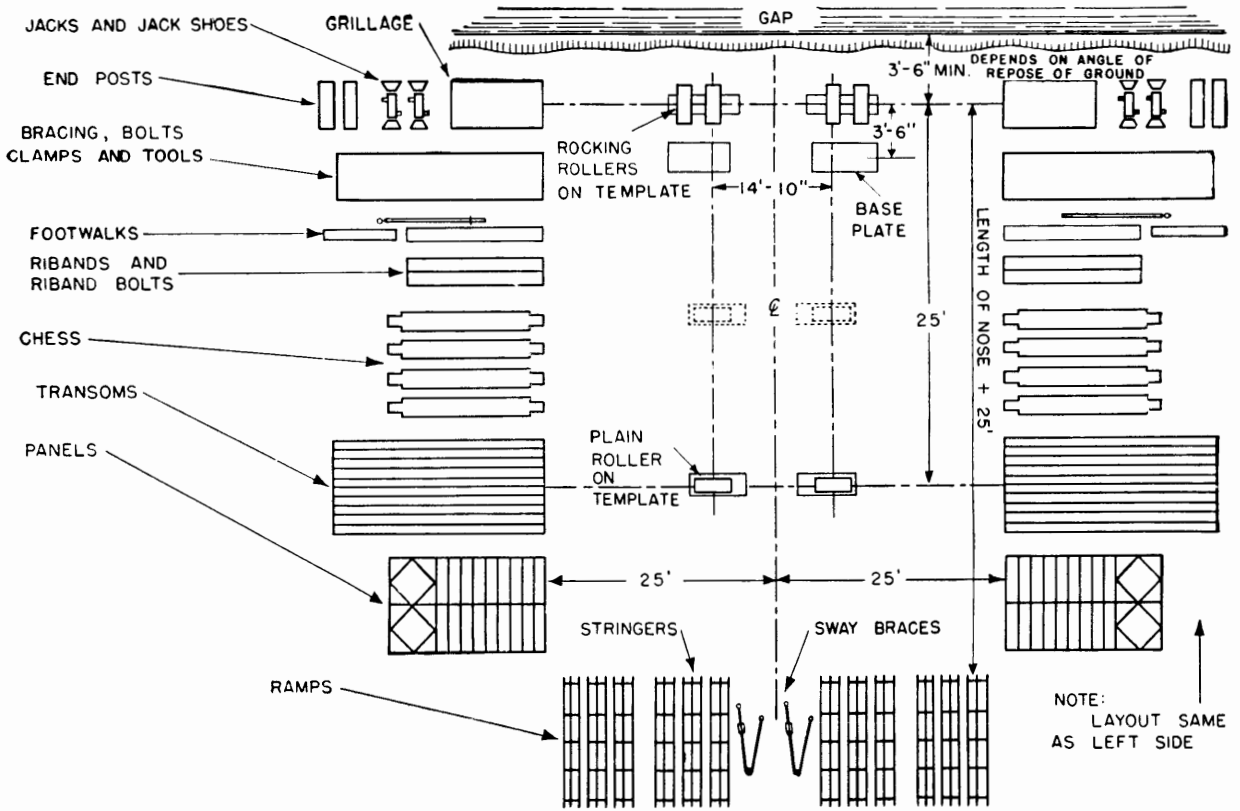


Figure 46. Lay-out of equipment at bridge site.

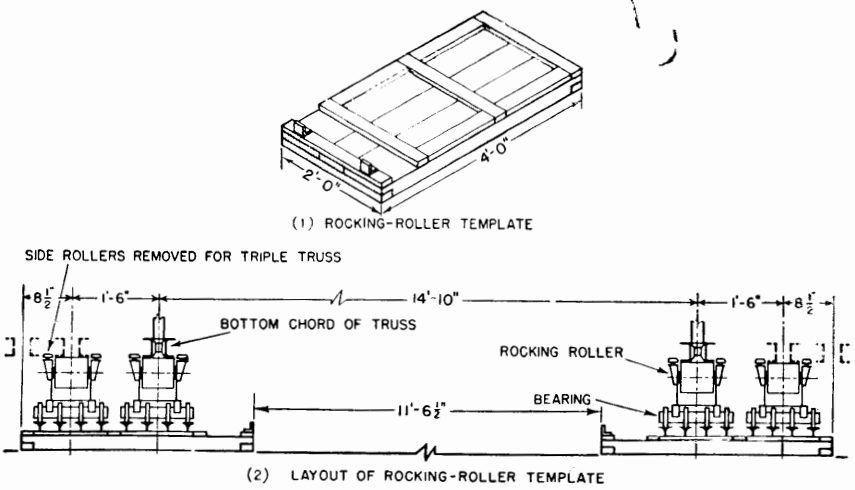


Figure 47. Lateral spacing of rocking-roller templates.

in figure 48. The center lines of the bearings are spaced opposite the inner and second dowel holes at each end of the transom.

(2) *Plain rollers.* (*a*) *Longitudinal spacing.* Two or more plain rollers are placed every 25 feet behind the rocking rollers to support the bridge during erection and launching (figs. 49 and 50). An extra set of plain rollers is temporarily used 12½ feet behind the rocking rollers to aid in inserting launching-nose links and provide clearance between links and the ground. Two plain rollers are used in place of rocking rollers on the far bank for SS bridges and DS bridges shorter than 90 feet.

(*b*) *Lateral spacing.* Plain-roller templates are used under the rollers and are spaced as shown in figure 50.

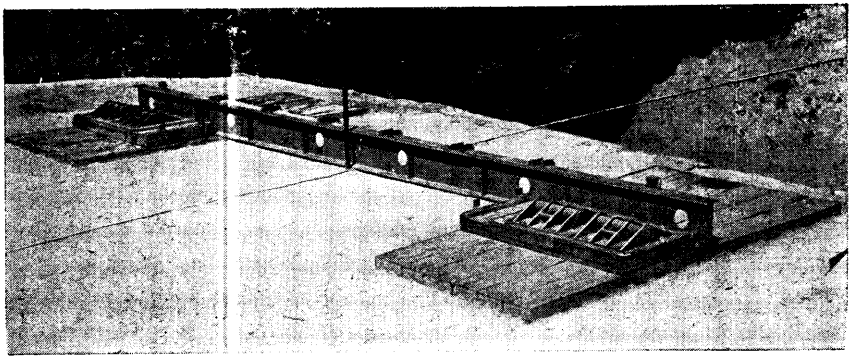
(3) *Elevation of rollers.* (*a*) All launching rollers (both plain and rocking), except the first temporary set of plain rollers, are set so their tops are in the same plane (fig. 49). Normally, this plane is level, but a slight inclination along the line of the bridge is permissible. The first temporary set of plain rollers is set 2 inches below the level of the other rollers. To aid in setting the rollers to the proper elevation, (1) and (2) of figure 51 show the height of the bottom bridge chord above the grillages when plain and rocking rollers are used.

(*b*) *Example of computations for determining elevation of rollers* (fig. 52):

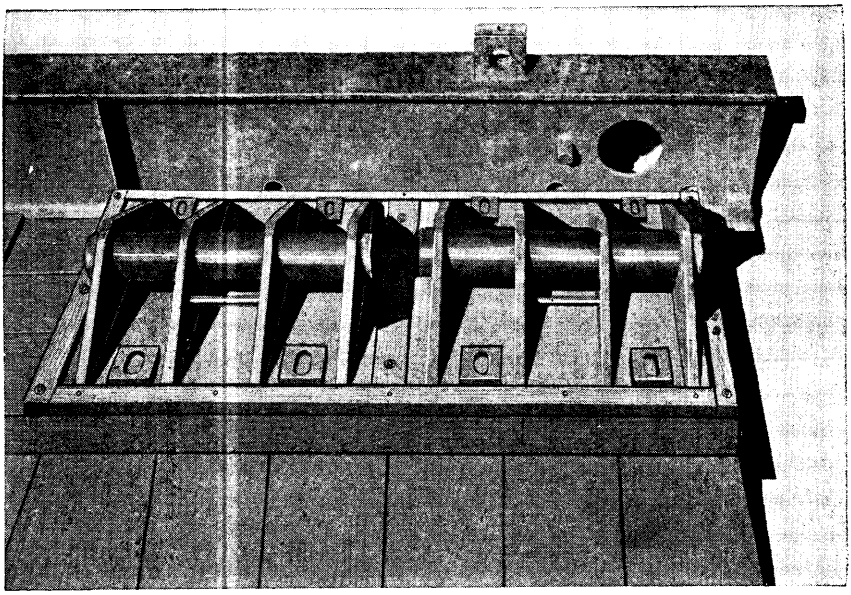
Given:

Length and type of bridge..... 160-foot triple-single

Distance between near- and far- bank rocking rollers ..... 155 feet



① *Transom used to position bearings*



② *To position bearings, place center of bearing opposite inner and second dowel holes at each end of transom*

Figure 48. Use of transom to locate bearings for rocking rollers or end bearings.

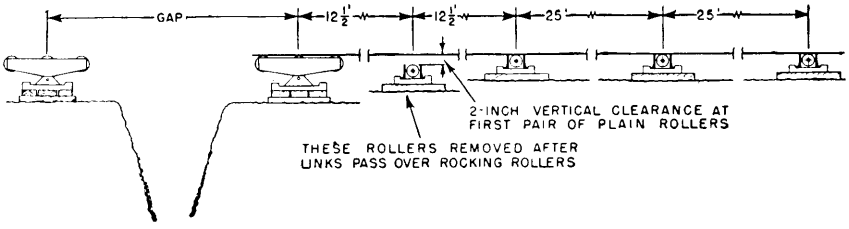


Figure 49. Longitudinal spacing of rollers.

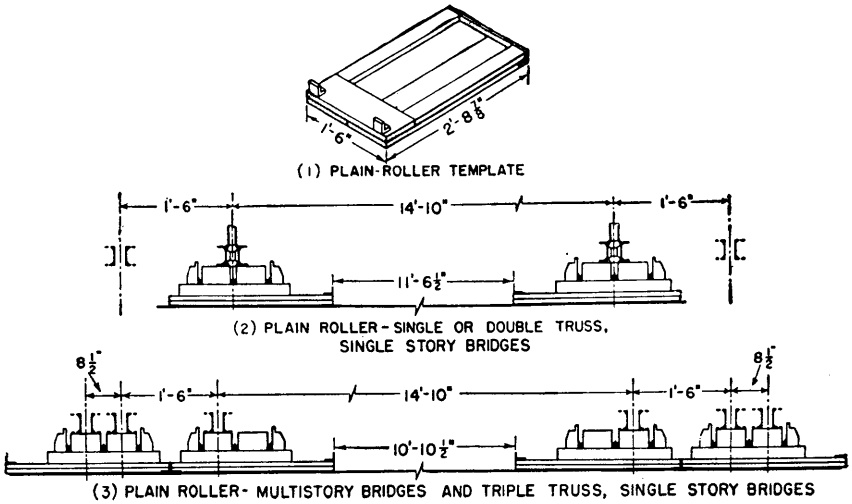


Figure 50. Lateral spacing of plain-roller templates.

Distance between near-bank rocking roller and rear plain roller	75 feet
Ground level at far-bank seat	39 inches above near-bank seat
Ground level at rear plain roller	24 inches above near-bank seat

Problem:

To determine what cribbing is needed under near-bank rocking roller to make tops of all rollers in same plane.

Solution:

1. Distance from base of rocking-roller template to top of rocking roller ((2), fig. 51) ..... $16\frac{5}{16}$ inches
   Distance from base of plain-roller template to top of plain roller ((1), fig. 51) ..... $8\frac{15}{16}$ inches
   Minimum height of grillage beneath plain and rocking rollers (ch. 10) .... 6 inches
2. Difference in elevation between top of far-bank rocking roller and top of rear plain roller = (39 in + 6 in + $16\frac{5}{16}$ in) − (24 in + 6 in + $8\frac{15}{16}$ in) = $22\frac{3}{8}$ inches.
3. Difference in elevation between top of rear plain roller and top of near-bank rocking roller to place rocking roller in same plane as other rollers = $22\frac{3}{8}\left(\frac{75}{75+155}\right) = 7\frac{5}{16}$ inches.

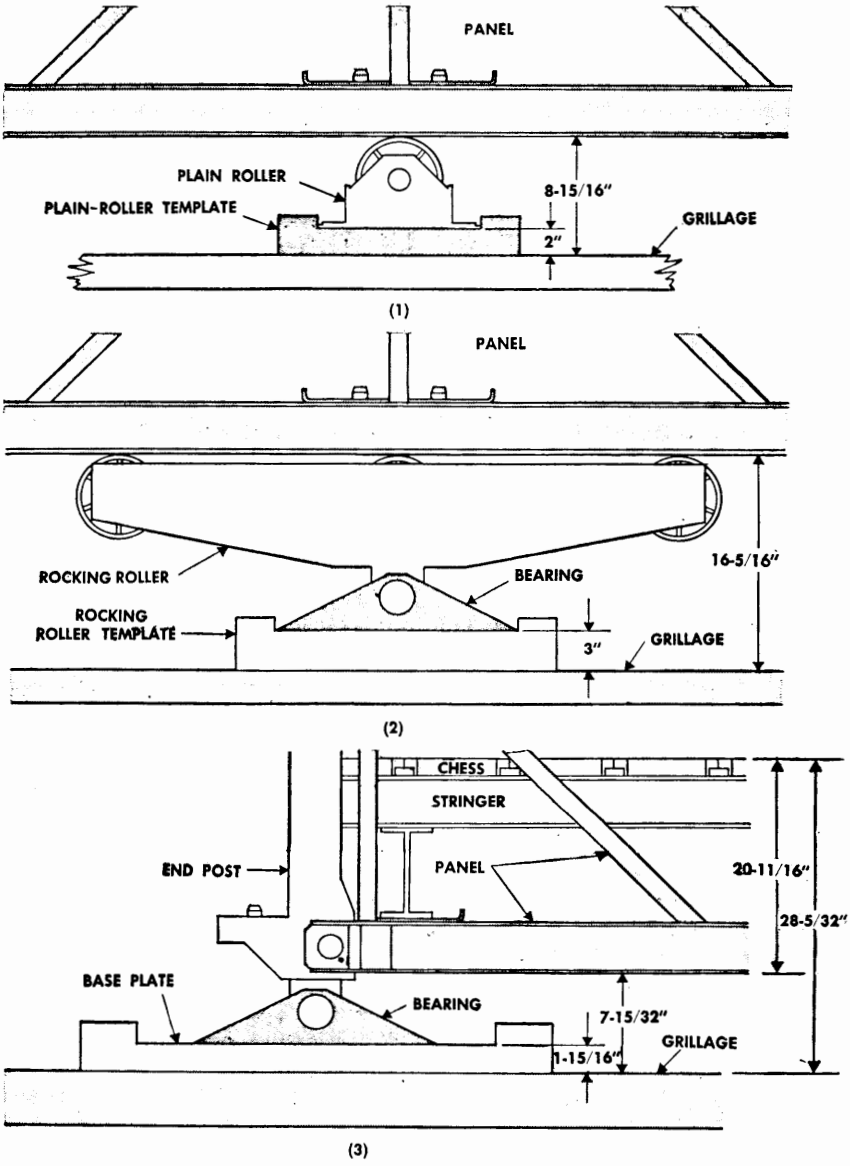


Figure 51. Height of bottom bridge chord above grillage.

4. Distance from ground to top of near-bank rocking roller = (24 in + 6 in + $8\frac{15}{16}$ in) + $7\frac{5}{16}$ in = $46\frac{1}{4}$ inches.
5. Grillage necessary under near-bank rocking roller = $46\frac{1}{4}$ in − $16\frac{5}{16}$ in = $29\frac{15}{16}$ inches.

Therefore use five layers of 6 inch by 6 inch grillage under the near-shore rocking roller template. To determine number and spacing of launching links see paragraph 90.

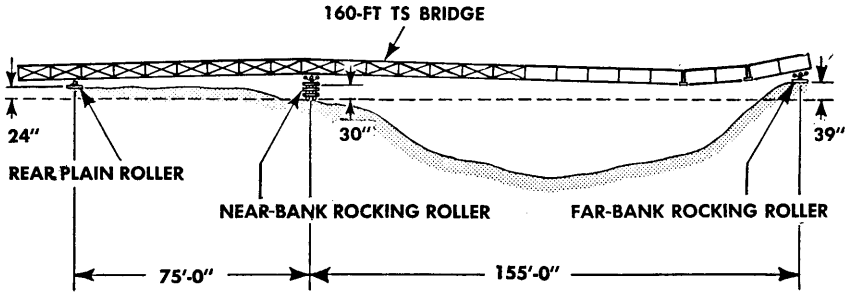


Figure 52. Example of grillage required under near-shore rocking rollers to make all rollers in the same plane.

b. BASE PLATES. Base plates for the end bridge bearings are placed at least 2½ feet and preferably 3½ feet behind the rocking rollers; otherwise, the rollers will interfere with the end post when the bridge is being jacked down (fig. 53). Base plates are spaced laterally as shown in figure 54. The base plates are set at an elevation to keep the slope of the ramp bays less than 10 to 1 for 50-ton or smaller loads and 20 to 1 for heavier loads. The height of the bridge floor above the grillage for determining the elevation of the base plate is shown in (3) of figure 51.

c. GRILLAGES. Figures 57 to 64 show distances from the center lines of the base plate and rocking rollers to outside edges of grillage for determining the area to be leveled off. The elevation of the grillage

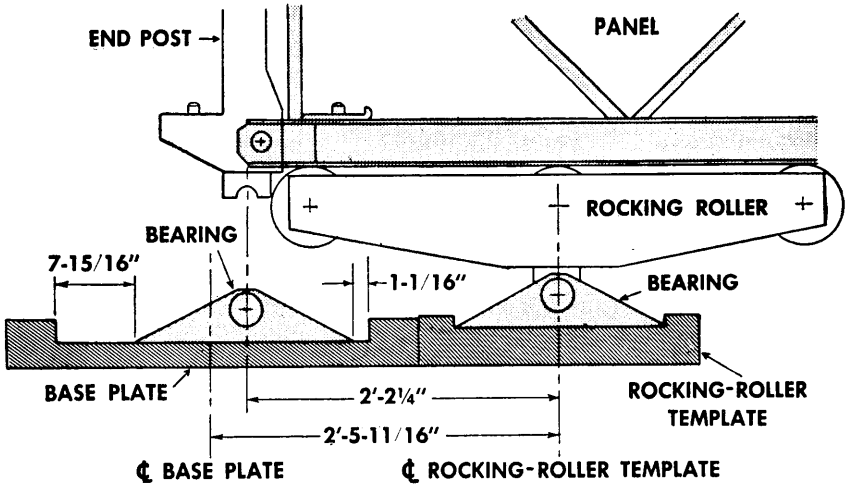


Figure 53. Rocking rollers and base plate at end of bridge. If rocking-roller template and base plate are back to back, the distance between their center lines is 2 feet 5 11/16 inches. Center line of bearing must be at least 2 feet 2¼ inches from center line of rocking rollers to clear roller overhang.

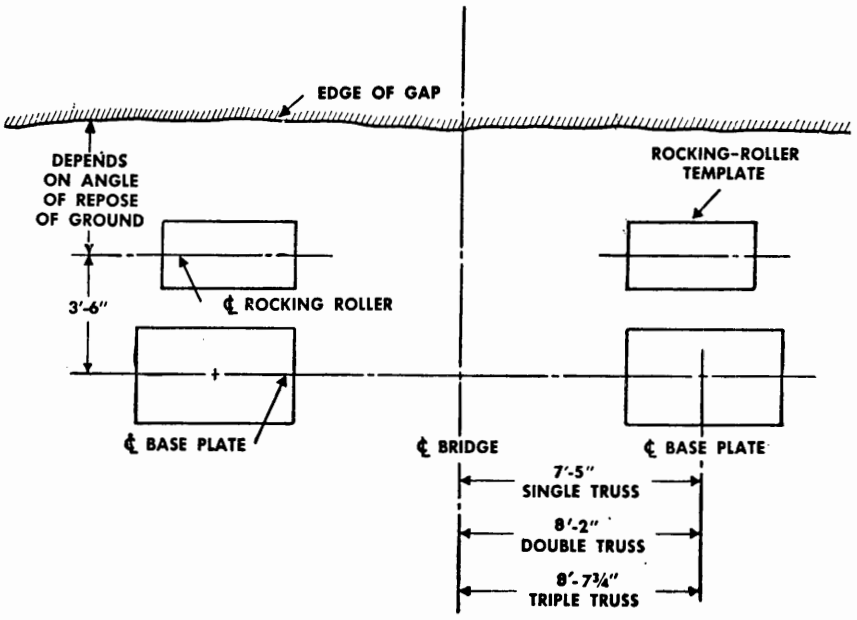


Figure 54. Lateral spacing of base plates.

is determined by the level of the rollers or base plate. The grillage can be blocked up or dug in as required.

78. Lay-out Drill

a. PERSONNEL. The preliminary work in preparing end supports is done by a lay-out party and an advance construction party. The lay-out party may consist of one officer, one noncommissioned officer, one enlisted man, and a driver; the advance construction party may consist of two squads.

b. EQUIPMENT. The lay-out party should have a hand level, level rod, steel measuring tape, tracing tape, pickets, hand ax, pneumatic reconnaissance boat, and wire. The advance construction party is equipped with normal squad pioneer and carpenter sets. The necessary grillage timbers are supplied in the grillage truck loads which arrive at the bridge site in advance of the bridge parts.

c. DRILL. (1) Stretch a wire across gap. Wire should be marked at 10-foot intervals.

(2) Determine minimum safe distance launching and landing rollers can be placed from edge of gap. Rollers must be behind natural angle on repose of bank.

(3) Decide on final span of bridge, making it *at least* 5 feet longer than span between launching and landing rollers.

(4) Continue center line of bridge for full length of estimated nose and tail of bridge.

(5) Use pickets to mark positions of launching, landing, and plain construction rollers, and base plates.

(*a*) Use *four* rocking rollers as launching rollers for all bridges except SS bridges and DS bridges shorter than 110 feet. For these bridges, use *two* rocking rollers.

(*b*) Use *one* rocking roller under each truss in *nose* as landing roller for all bridges except SS and DS bridges shorter than 90 feet. For these bridges, use *one* plain roller under each truss in nose.

(*c*) Place base plate at least 2½ feet and preferably 3½ feet behind launching and landing rollers.

(*d*) Place plain rollers in pairs at 25-foot intervals back of launching rollers. For double-story construction, place two extra plain rollers 50 feet behind launching rollers. Place another pair of plain rollers 12½ feet back of launching rollers.

(6) Use level to make profile along center line of bridge as far back as full length of tail. Then take cross sections (at right angles to center line of bridge) at positions of rollers and base plates. From the known ground level, calculate height of cribbing or depth of excavation needed for rollers. All launching, landing, and construction rollers should be on same level, if possible, except the plain rollers 12½ feet back of the launching rollers. These should be 2 inches below the others. If necessary to launch bridge on an incline, rollers should be in *one* inclined plane and a holdfast should be provided for a snubbing line to tail of bridge.

(7) Estimate bearing capacity of ground and select type of grillage required from table 31 or 32. Grillage is required under plain-roller template only when two rollers are used side by side and bearing capacity of soil is less than 2 tons per square foot.

(8) Make a sketch of the bridge lay-out for use in computing launching-nose requirements. Figure 55 is a typical sketch.

(9) At earliest possible moment, start advance construction party on leveling and excavating for grillage and template positions. Figure 54 shows the dimensions to the center lines of the base plates and rocking-roller templates.

(10) Mark out position for all stock piles 25 feet to either side of center line. Mark center of piles in following order behind launching rollers: small parts, footwalks, ribands, chess, transoms, panels, stringers, and sway braces. The panel pile should normally be about 40 feet behind launching rollers (fig. 46). Stringers and sway braces should be at tail of bridge.

(11) When grillage areas are level, construct grillages and crib up rollers to desired height.

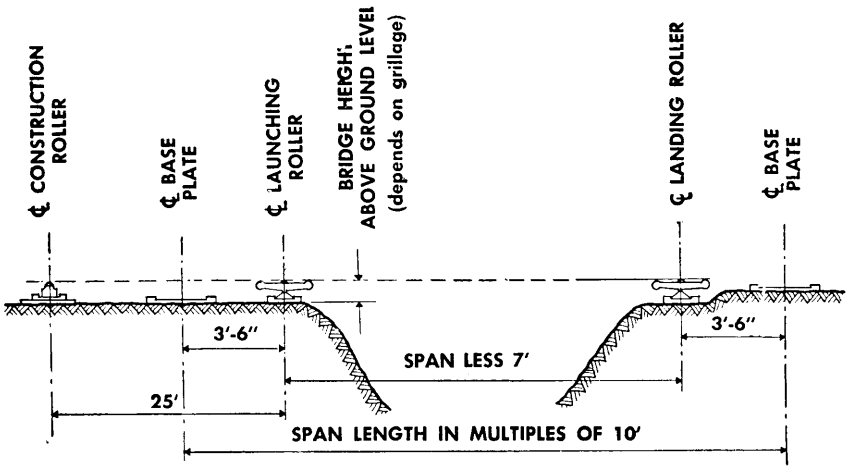


Figure 55. Sketch of proposed lay-out of a panel bridge.

(12) Check lay-out to make sure that—
(*a*) Grillage is adequate for loads.
(*b*) Drainage around grillages is adequate.
(*c*) Rollers are spaced properly.
(*d*) Rollers are in line.
(*e*) Rollers are square to center line.
(*f*) Rollers are opposite one another laterally.
(*g*) Tops of rollers are in one plane.
(13) Begin assembly of bridge.

CHAPTER 10

END SUPPORTS

79. Scope

This chapter describes standard end supports for the panel bridge.

80. Grillages for End Bearings and Rocking Rollers

a. PURPOSE. The end posts at each end of the bridge are supported by bearings set on base plates. During launching, the entire launching weight of the bridge is carried by the near bank rocking rollers, which set on rocking-roller templates. If the bearing pressure under the base plate or rocking-roller template exceeds the safe bearing capacity of the ground, grillages are used to spread the load over a larger area (fig. 56). Grillages also serve as blocking to raise base plates or rollers to the desired level.

b. DESCRIPTION. Grillages are made of timbers laid side by side under the base plate or roller template. When two or more layers are used, the added layers are laid crosswise. Standard grillages have been designed to use timbers in panel bridge set and other standard size timbers. The designs take into account the bending stress, shear stress, and bearing stress in the grillage timbers as well as the allowable bearing pressure on the soil.

(1) *Standard grillages using timbers supplied in panel bridge set.* The panel bridge set supplies 144 6- by 6-inch timbers 4½ feet long, and 48 3- by 6-inch timbers 4½ feet long for grillage. Standard grillages

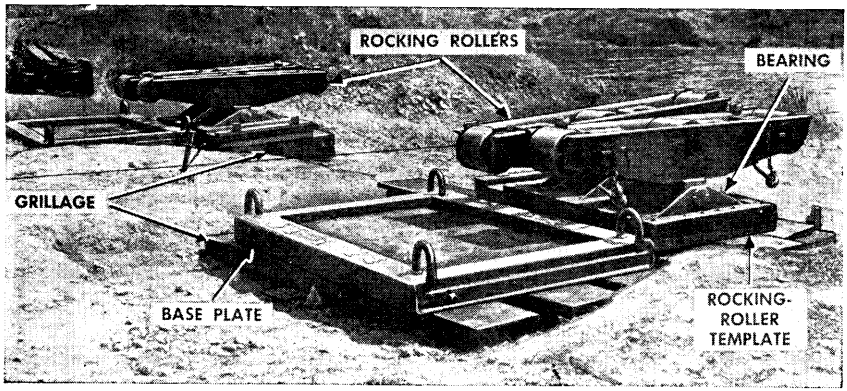
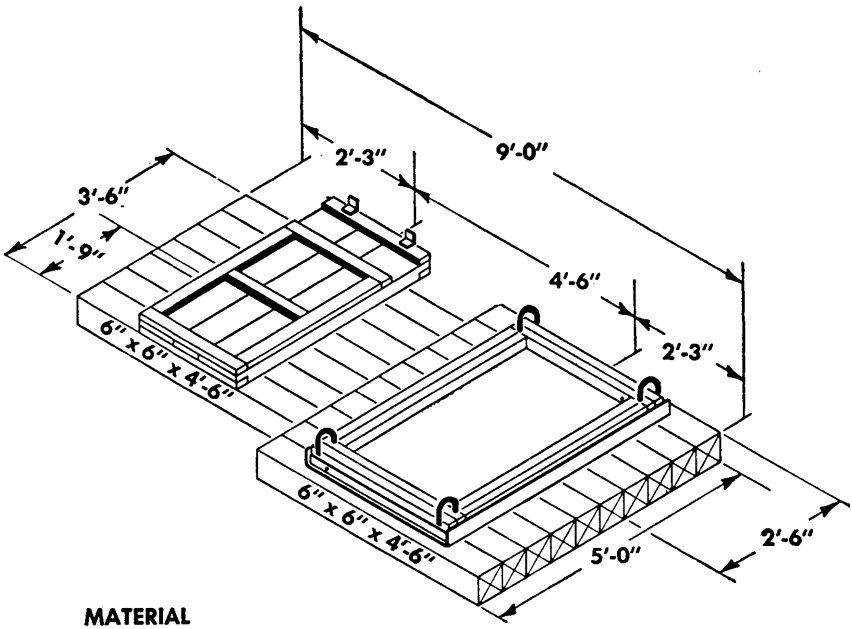
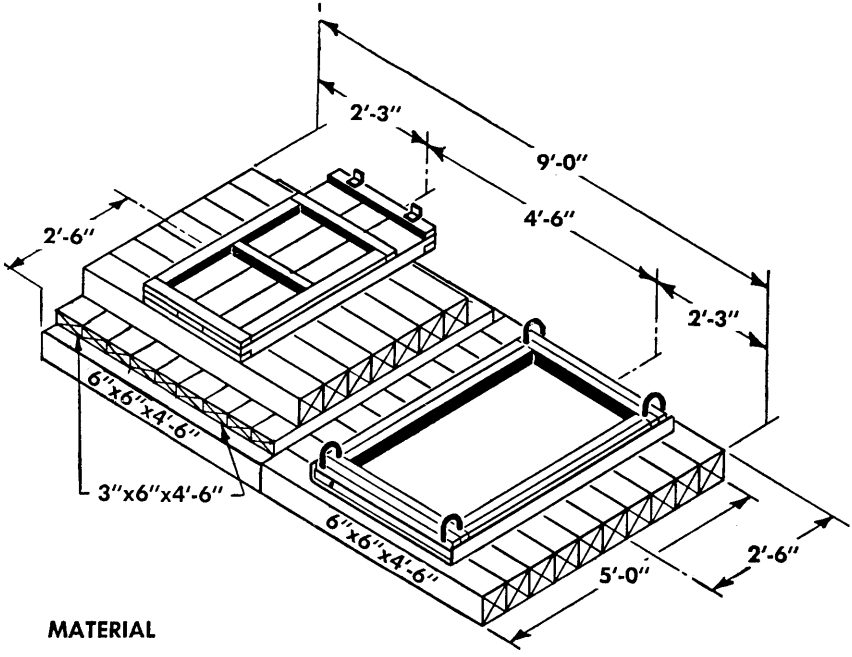


Figure 56. Base plate and rocking rollers in position on grillage before launching bridge.



MATERIAL
17 PCS 6" x 6" x 4'-6"

Figure 57. Grillage built from panel bridge set, type 1.



MATERIAL
27 PCS 6"x6"x4'-6"
9 PCS 3"x6"x4'-6"

Figure 58. Grillage built from panel bridge set, type 2.

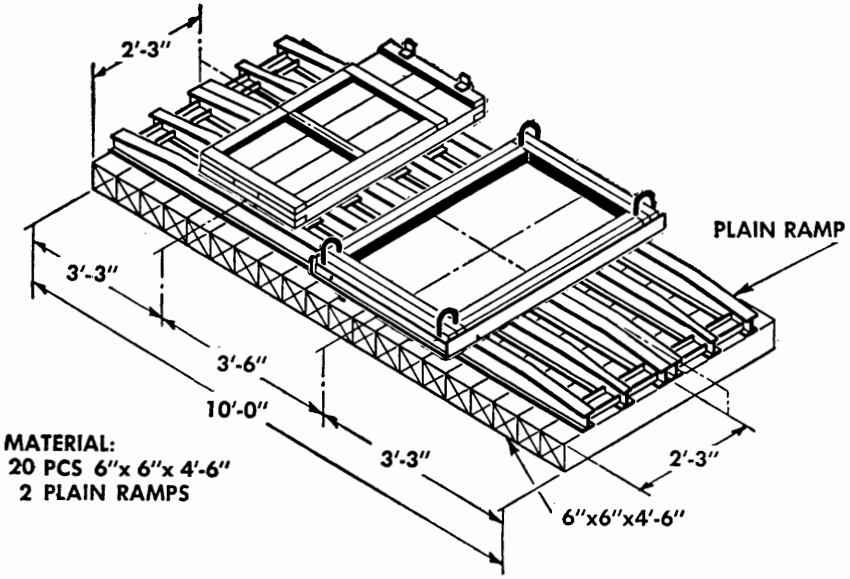


Figure 59. Grillage built from panel bridge set, type 3.

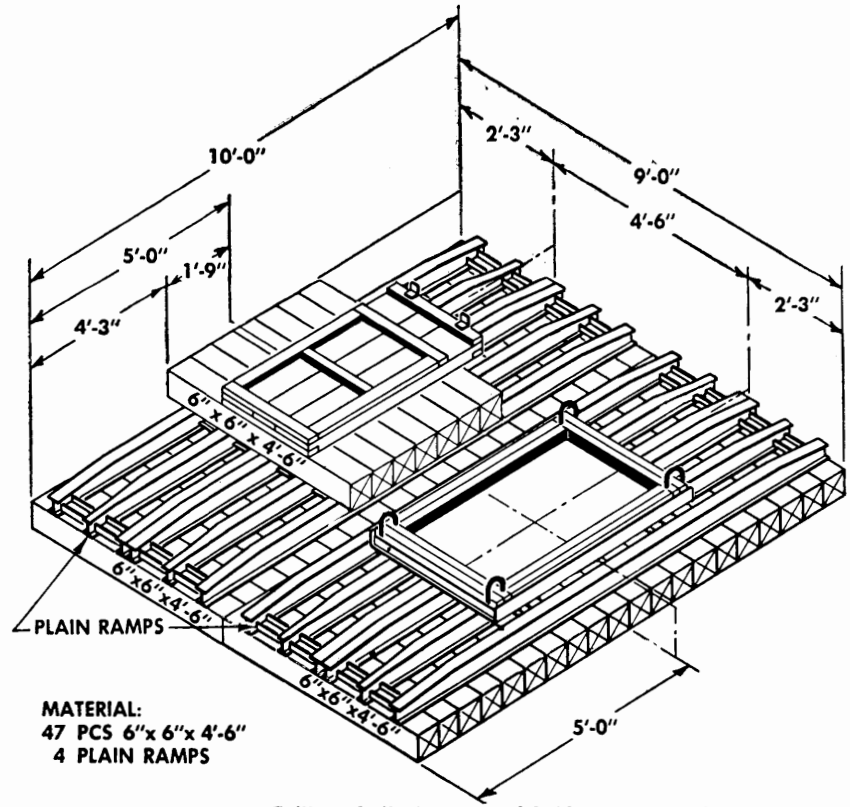


Figure 60. Grillage built from panel bridge set, type 4.

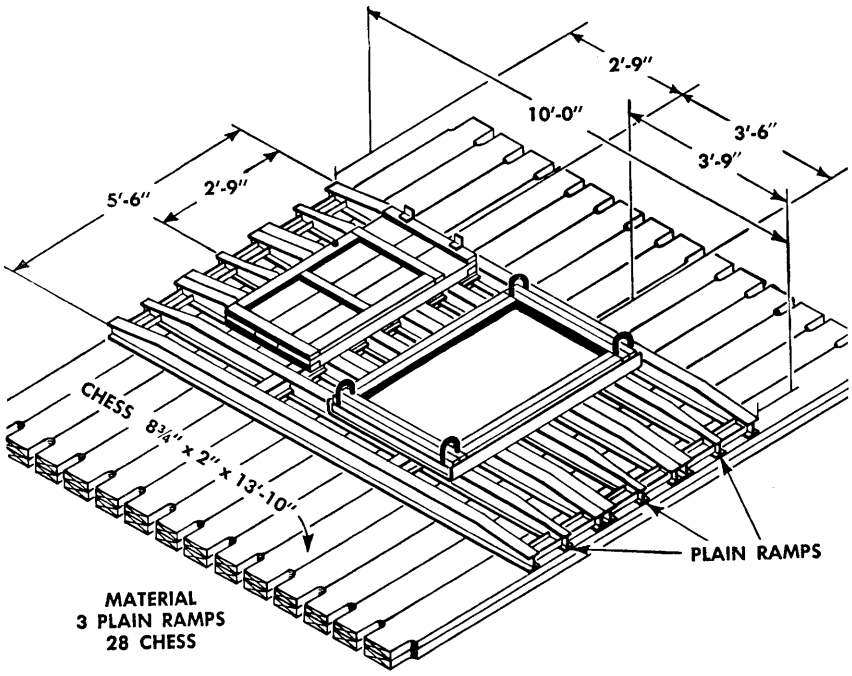


Figure 61. Grillage built from panel bridge set, type 5.

using these timbers and panel bridge parts are illustrated in figures 57 through 61. Their capacities are given in table 31.

(2) *Grillages using timbers not supplied in panel bridge set.* On soft soils, some of the heavier bridges will require larger grillages than can be built from the timbers supplied in the set. For these bridges, grillages built from 8- by 8-inch timbers are illustrated in figures 62 through 64. Their capacities are given in table 31.

(3) *Nonstandard grillages.* Other size timbers can be used if each layer of improvised grillage is the same length as a layer of the corresponding standard grillage and if it is at least as thick and as wide.

c. SELECTION OF GRILLAGE. The bridge load, the allowable bearing pressure on the soil, and the capacity of the grillage determine the type of grillage needed. Table 32 gives the type of grillage needed for various spans and constructions of panel bridge. Whenever possible, provide heavy enough grillage so it will not have to be replaced if the bridge is later reinforced to a higher class. Changing a grillage under a bridge is difficult and takes time.

(1) *Load on grillage.* Table 33 gives the load on the grillage at one corner of the bridge. Note that in some bridges the launching-roller reaction is greater than the base-plate reaction.

Table 31. Capacities of Grillages Illustrated in Figures 57 to 64

Safe bearing pressure of soil (tons per sq ft)	Maximum safe load on base plate / Maximum safe load on rocking-roller template							
	No grillage	Material used							
		Supplied in panel bridge set					Not in panel bridge set		
		17 pcs 6"x6"x4'6"	27 pcs 6"x6"x4'6" 9 pcs 3"x6"x4'6"	2 ramps 20 pcs 6"x6"x4'6"	4 ramps 47 pcs 6"x6"x4'6"	3 ramps 28 chess	3 pcs 8"x8"x6'0" 5 pcs 8"x8"x8'0" 12 pcs 8"x8"x12'0"	4 transoms 10 pcs 2"x6"x4'6" 4 pcs 6"x6"x4'6" 30 pcs 8"x8"x12'0"	3 ramps 15 pcs 8"x8"x15'0"
		Figure reference							
		57	58	59	60	61	62	63	64
		Type of grillage							
		1	2	3	4	5	6	7	8
0.5	7 / 3	11 / 8	11 / 10	13 / 9	22 / 22	41 / 30	30 / 17	87 / 60	43 / 31
1.0	13 / 6	22 / 16	22 / 20	26 / 19	45 / 45	46 / 39	59 / 34	90 / 60	86 / 60
2.0	27 / 12	45 / 31	45 / 40	51 / 37	71 / 57	63 / 45	75 / 34	90 / 60	99 / 60
2.5	34 / 15	56 / 39	56 / 51	61 / 46	71 / 57	79 / 57	75 / 34	90 / 60	99 / 60
3.5	47 / 21	79 / 45	79 / 60	61 / 60	71 / 57	99 / 60	75 / 34	90 / 60	99 / 60

Table 32. Types of Grillage Needed[1]

Construction	Safe soil pressure (tons per sq. ft.)	Span in feet													
		30	40	50	60	70	80	90	100	110	120	130	140	150	160
SS	0.5	5, 7, 8	5, 6, 7, 8	5, 6, 7, 8	4	4	4	4	4						
	1.0	4	3	3	1	1	1	1	1						
	2.0	1	[2]	[2]	[2]	[2]	1	1	1						
	2.5	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]						
	3.5	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]						
DS	0.5	.....	.....	7	7	7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8		
	1.0	.....	.....	6, 7, 8	6, 7, 8	4	4	4	4	4	4	4	4		
	2.0	.....	.....	4	3	1	1	1	1	1	1	1	1		
	2.5	.....	.....	1	1	1	1	1	1	1	1	1	1		
	3.5	.....	.....	1	[2]	[2]	[2]	[2]	[2]	1	1	1	1		
TS	0.5	.....	.....	.....	.....	.....	7	7	7, 8	5, 7, 8	5, 7, 8	5, 7, 8	7	7, 8	5, 7, 8
	1.0	.....	.....	.....	.....	.....	6, 7, 8	6, 7, 8	4	4	4	4	4	4	4
	2.0	.....	.....	.....	.....	.....	4	3	1	1	1	1	2	1	1
	2.5	.....	.....	.....	.....	.....	3	1	1	1	1	1	1	1	1
	3.5	.....	.....	.....	.....	.....	1	1	1	1	1	1	1	1	1

Construction	Safe soil pressure (tons per sq. ft.)	Span in feet													
		100	110	120	130	140	150	160	170	180	190	200	210		
DD	0.5	7	7	7	7	7	7	7	7	7					
	1.0	7, 8	6, 7, 8	6, 7, 8	4	4, 5, 7, 8	4, 7, 8	4, 5, 7, 8	4, 7, 8	4, 5, 7, 8					
	2.0	4	4	3	2	2	4, 5, 7, 8	2	4, 5, 7, 8	2					
	2.5	3	1	1	1	1	2	1	2	1					
	3.5	1	1	1	1	1	1	1	1	1					
TD	0.5	.....	7	7	7	7	7	7	7	7	7				
	1.0	.....	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8				
	2.0	.....	4, 7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8				
	2.5	.....	4, 5, 7, 8	3	2	2	2	2	2	2	2				
	3.5	.....	1	1	1	2	2	2	2	2	2				

DT	0.5	.....	.....	.....	7		7	7	7	7	7	7	7	
	1.0	.....	.....	.....	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	
	2.0	.....	.....	.....	7, 8	4, 7, 8	4, 7, 8	7, 8	7, 8	7, 8	4, 7, 8	4, 7, 8	4, 7, 8	
	2.5	.....	.....	.....	5, 7, 8	4, 5, 7, 8	4, 5, 7, 8	7, 8	7, 8	7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8	
	3.5	.....	.....	.....	2	2	2	2	2	2	2	2	2	
TT	0.5	.....	.....	.....	.....	.....	.....	.....	7	7	7	7	7	
	1.0	.....	.....	.....	.....	.....	.....	.....	7, 8	7, 8	7, 8	7, 8	7, 8	
	2.0	.....	.....	.....	.....	.....	.....	.....	7, 8	7, 8	7, 8	7, 8	4, 7, 8	
	2.5	.....	.....	.....	.....	.....	.....	.....	7, 8	7, 8	5, 7, 8	5, 7, 8	4, 5, 7, 8	
	3.5	.....	.....	.....	.....	.....	.....	.....	5, 7, 8	5, 7, 8	2	2	2	

[1] See figures 57 through 64 for illustrations of grillages.

[2] No grillage needed under base plate or rocking roller template.

Table 33. Maximum base-plate and launching-roller reactions in Tons on Grillage at One Corner of Bridge

SS	Span in feet	30	40	50	60	70	80	90	100		
	Safe capacity	40	32	28	26	22	18	13	10		
	Caution capacity	55	45	38	35	31	23	19	13		
	Base-plate reaction[1]	31	26	24	21.8	21	18	17	15		
	Launching-roller reaction[2]	5.7	7.4	8.9	10.7	12.7	13.9	15.9	14.4		
DS	Span in feet	50	60	70	80	90	100	110	120	130	140
	Safe capacity	80	67	64	51	44	31	23	18	13	10
	Caution capacity	100	84	80	64	55	40	34	23	19	13
	Base-plate reaction[1]	56	48	45	39	35	30	27	23	22	20
	Launching-roller reaction[2]	10.5	12.8	14.5	16.8	18.8	20.5	22.8	24.9	26.8	23.9
TS	Span in feet	80	90	100	110	120	130	140	150	160	
	Safe capacity	80	62	52	40	34	23	18	13	10	
	Caution capacity	100	78	65	50	43	32	23	19	13	
	Base-plate reaction[1]	59	50	43.5	38	34.5	31	27	26	25	
	Launching-roller reaction[2]	19.0	21.5	23.5	26.0	28.0	30.5	33.0	30.5	29.8	
DD	Span in feet	100	110	120	130	140	150	160	170	180	
	Safe capacity	75	64	50	40	31	23	19	13	10	
	Caution capacity	94	80	63	51	44	32	29	19	13	
	Base-plate reaction[1]	60	53	47	42	39	35	35	32	30	
	Launching-roller reaction[2]	26.8	29.8	32.0	34.8	38.3	41.0	38.0	40.8	38.3	
TD	Span in feet	110	120	130	140	150	160	170	180	190	
	Safe capacity	80	70	57	48	40	31	23	18	12	
	Caution capacity	100	88	75	61	50	43	31	23	16	
	Base-plate reaction[1]	68	62	57	53	49	48	44	42	40	
	Launching-roller reaction[2]	35.8	39.3	43.3	46.8	50.3	51.0	49.3	47.0	46.0	

DT	Span in feet	130	140	150	160	170	180	190	200	210
	Safe capacity	80	67	65	56	50	40	31	23	18
	Caution capacity	100	87	81	70	63	50	44	31	23
	Base-plate reaction[1]	73	67	66	64	63	60	58	54	51
	Launching-roller reaction[2]	47.5	50.8	54.8	59.0	59.8	59.5	56.8	55.5	56.3
TT	Span in feet	170	180	190	200	210				
	Safe capacity	70	57	50	40	29				
	Caution capacity	88	75	64	50	36				
	Base-plate reaction[1]	85	82	78	75	69				
	Launching-roller reaction[2]	60	60	60	60	60				

[1] Includes weight of footwalks, ramps, bearings, and base plate. Live load assumed to be caution load on center line of bridge.
[2] Includes weight of rocking rollers, bearings, and template. Bridge launched without footwalks.

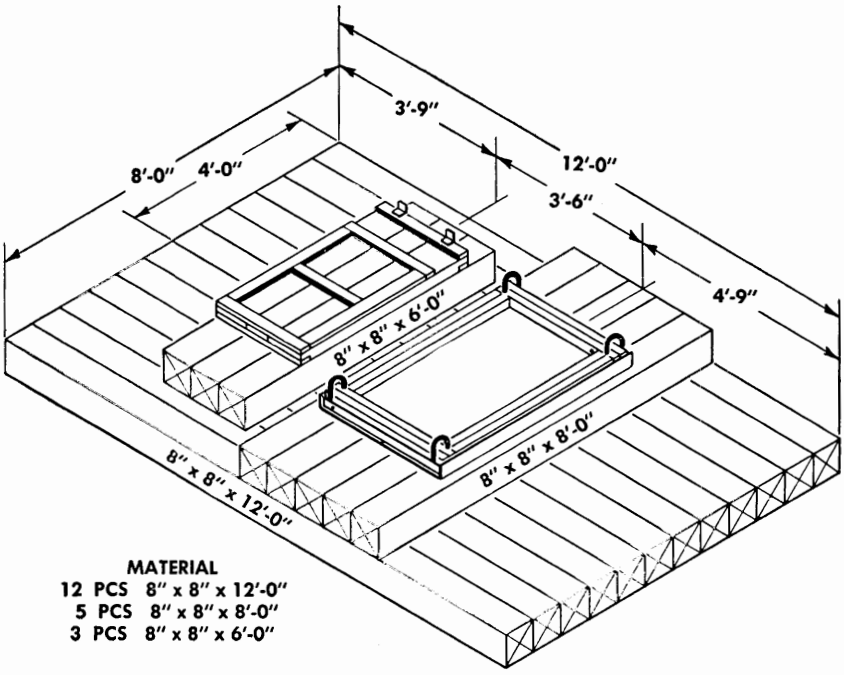


Figure 62. Grillage using timbers not supplied in panel bridge set, type 6.

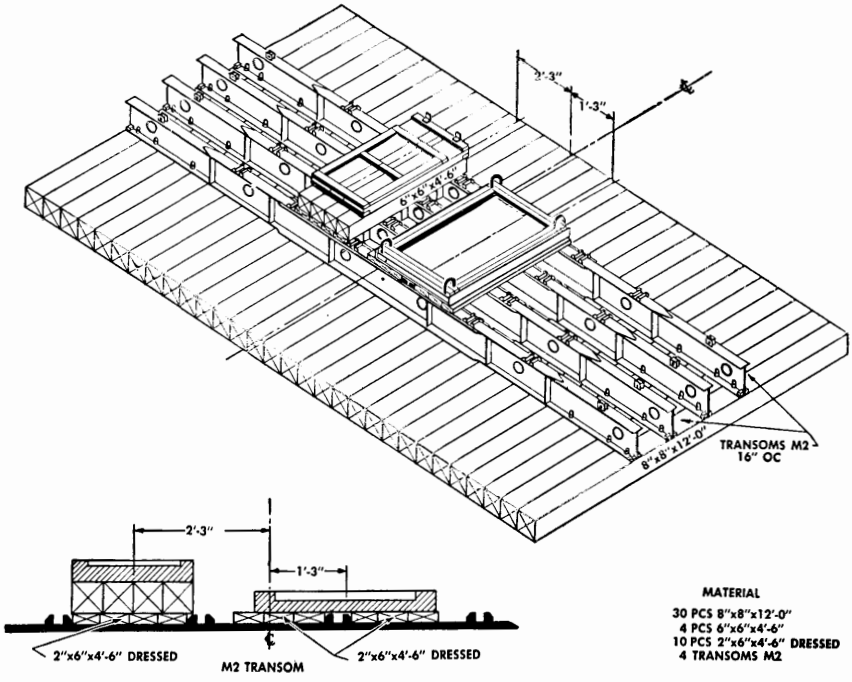


Figure 63. Grillage using timbers not supplied in panel set, type 7.

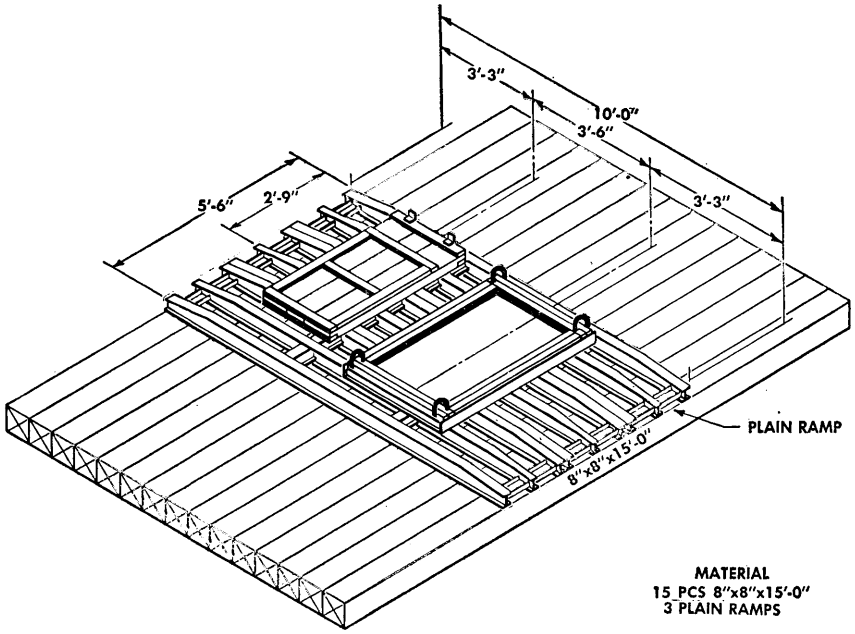


Figure 64. Grillage using timbers not supplied in panel bridge set, type 8.

Table 34. Safe Bearing Pressure on Various Soils

Description of soil	Safe bearing pressure (tons per sq ft)
Silts and Clays (clays, silts, very fine sands, or mixtures of these containing few coarse particles of sand or gravel. Classification[1]—MH, CH, OH, ML, CL, OL):	
Soft muds or marshy soils	0.5
Stiff silts or clays	2
Hard and dry clays	4
Sands (sands and well-graded sandy soils containing some silt and clay. Classification[1]—SW, SC, SP, SF):	
Very sandy soils and loose bank or beach sand	1.5
If grillage is buried 1½ feet	2.5
Cemented sands (soft sandstone)	5
Gravels (gravel and well-graded gravelly soils containing some sand, silt, and clay. Classification[1]—GW, GC, GP, GF):	
Bank gravel and well graded gravelly soils	2
If grillage is buried 1½ feet	3
Compact gravelly soils or cemented gravels	6
Rocks:	
Poor quality rock, soft and fractured; also hardpan	5
Good quality rock; hard and solid	10[2]

[1] See table I, FM 5-10.
[2] Minimum.

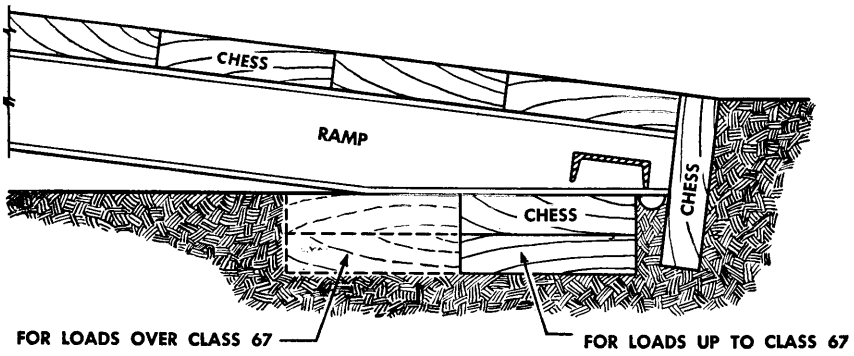


Figure 65. Support for end of ramp.

(2) *Allowable soil pressure.* Table 34 gives the safe bearing pressure in tons per square foot on various soils. A careful evaluation of the soil character is essential to prevent grillage failures. Note that in sandy or gravelly soils, the bearing power of the soil is increased when the grillage is dug in so that it bears on the soil 1½ or more feet below the surrounding surface. See table I, FM 5–10 for a more detailed description of the soil classification.

81. Supports for Ramps

a. Support for End of Ramp. The end of the ramp will carry about one-quarter of the weight of the heaviest tank to pass over it when ramp is supported at midspan. If there is no midspan support, the end of the ramp will carry about four-tenths of the weight of the tank. One chess or two chess side-by-side are laid in two layers under the tapered end of the ramp to provide the necessary bearing area on the soil. If greater area is needed for heavy loads on very soft soil, footings are used under the chess. On soil capable of supporting 2 tons per square foot, two chess under the tapered end of the ramp are enough for bridges up to class 67. For higher capacity bridges, four chess are used. (See fig. 65.) One chess on edge at the end of the ramp serves as an end dam so the approach can be made level with the ramp floor.

b. Midspan Ramp Supports. (1) For loads of 45 tons or over, each ramp section must be supported at its midpoint by cribbing and wedges (fig. 66). This support will carry one-half of the class of the vehicle passing over, and the area of the base of the cribbing should be large enough to spread the load over the soil without exceeding the allowable bearing pressure on the soil. On soil capable of supporting 2 tons per square foot, two chess side-by-side under the cribbing provide enough area for all bridges.

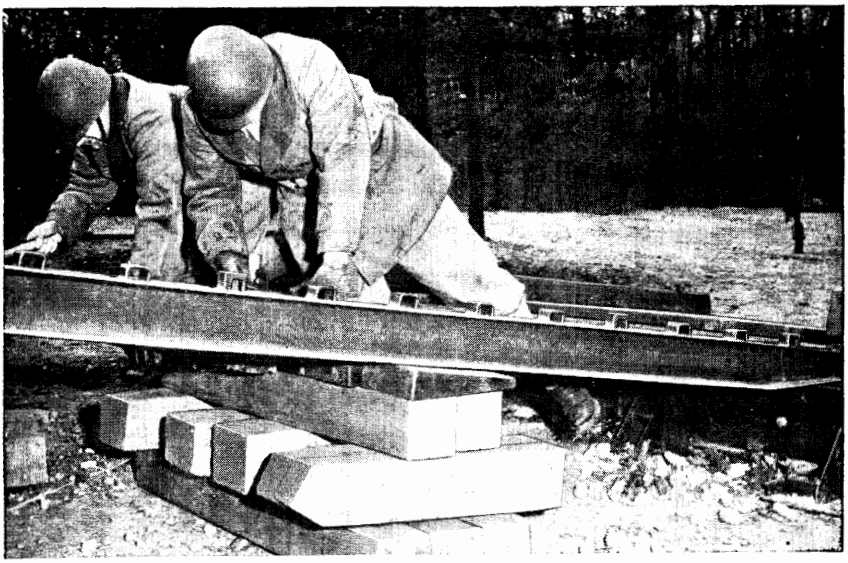


Figure 66. Cribbing and wedging ramp at midpoint to carry loads of 45 tons or over.

(2) An alternate method for loads of 45 tons or over is to make the ramp level, with at least 3½ feet of the ramp supported on the abutment (fig. 67).

c. PEDESTAL SUPPORTS. Because the slope of the ramp should not exceed 10 to 1, it may be necessary to use two ramp bays. The junction of the two ramp bays rests on a transom supported by four ramp pedestals spaced as shown in figure 68. These pedestals take two-thirds of the class of the vehicles passing over and must be set on enough grillage to spread the load over the soil. Three 6- by 6-inch timbers 4 feet 6 inches long under each pair of pedestals provide enough area for 40-ton loads on soil that will carry 2 tons per square foot. For heavier loads, three chess are placed side-by-side under the 6- by 6-inch timbers.

82. Supports for End Transom

For loads of 39 tons or more, cribbing and wedges are used under the midpoint of the end transom (fig. 69). This support will carry four-tenths of the weight of the heaviest tank to pass over, and the area of the base of the cribbing should be large enough to spread the load over the ground without exceeding the allowable bearing pressure on the soil. Seven 6- by 6-inch timbers 4 feet 6 inches long laid side-by-side provide enough area for all the bridge loads on soil that will carry 2 tons per square foot.

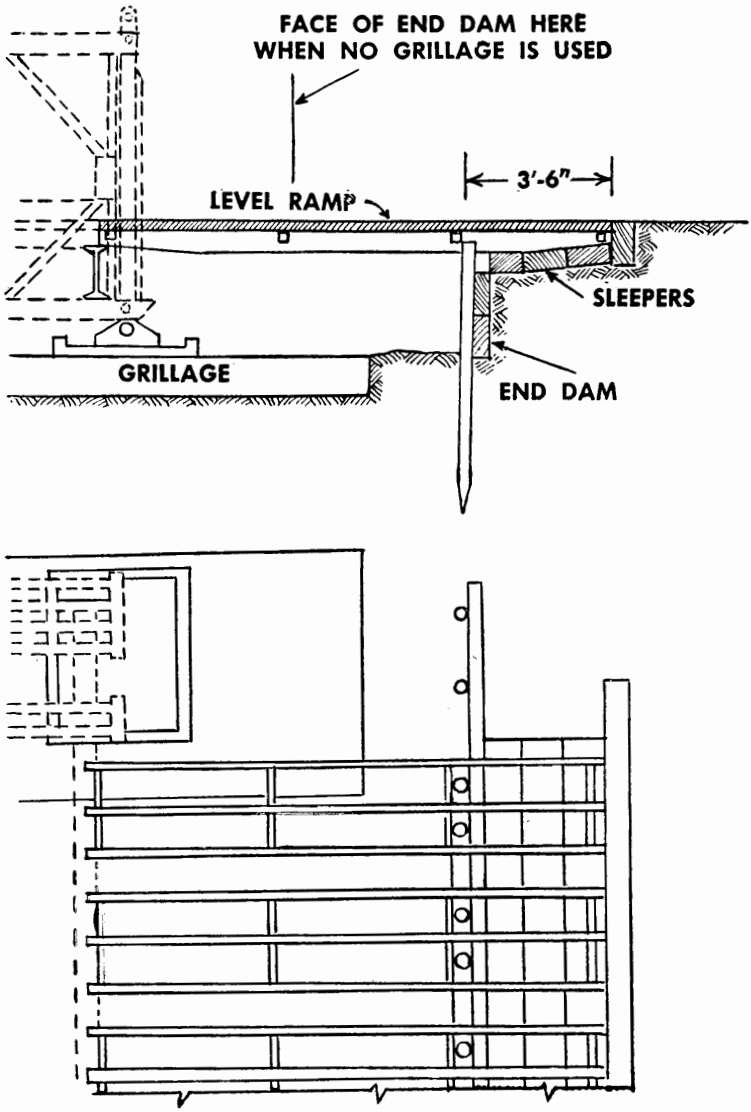


Figure 67. Level 10-foot ramp for loads of 45 tons or over.

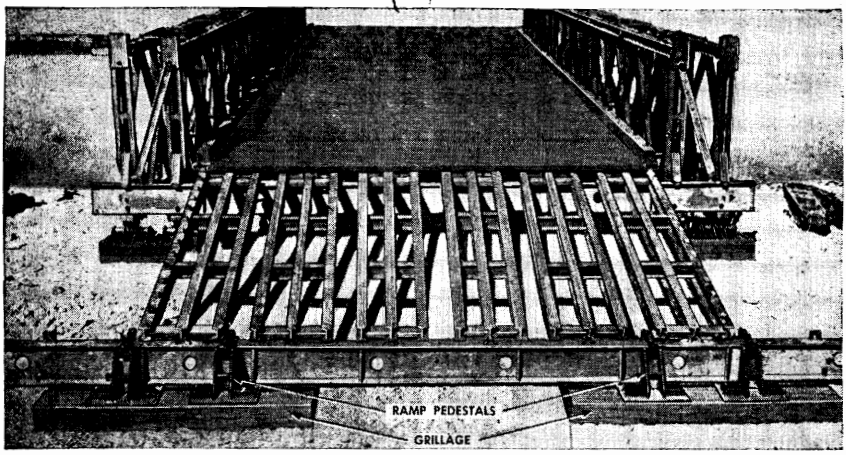


Figure 68. Ramp pedestals in place in two-bay ramp. Each pair of pedestals rests on a grillage of three 6- by 6-inch timbers 4 feet 6 inches long for loads up to 40 tons on soil which will carry 2 tons per square foot.

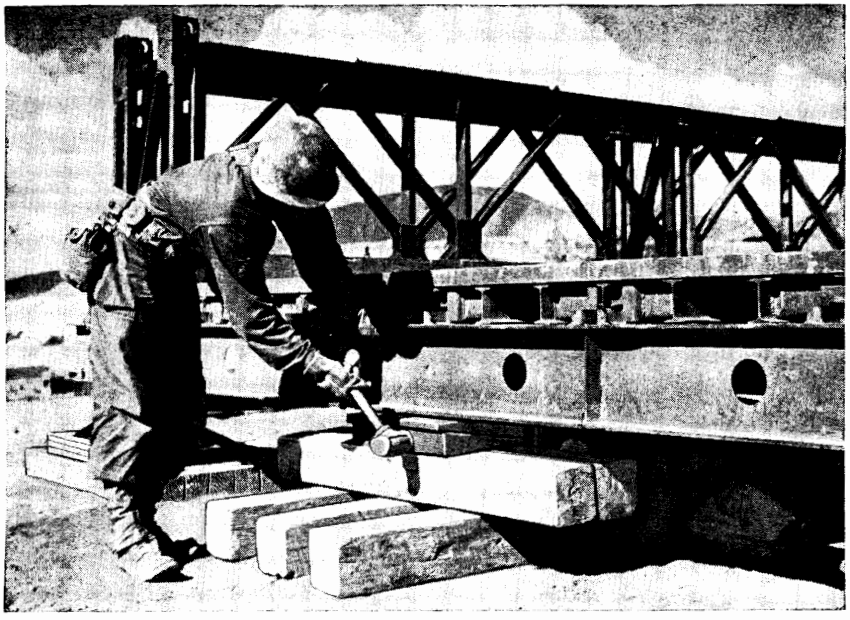


Figure 69. Cribbing and wedging under center of end transom to carry loads of 39 tons or over.

CHAPTER 11

CONSTRUCTION OF SINGLE-STORY BRIDGES

Section I. GENERAL

83. Site Lay-out

The lay-out of supplies and the positioning of rollers and grillage are given in chapter 9.

84. Grillage

Chapter 10 gives the types of grillage to be used for various ground pressures. When the span and construction of the bridge have been decided, the type of grillage required must be selected according to the bearing pressure of the ground.

85. Methods of Launching

a. NORMAL METHOD. The panel bridge is normally launched by the cantilever method employing a skeleton launching nose. This is generally the easiest and quickest procedure. The bridge is assembled on rollers on one bank and pushed across the gap, with enough weight kept behind the rollers to balance the bridge and prevent its tipping into the gap. A skeleton framework, called a launching nose, placed on the front of the bridge assists its travel into position on the far side. With this method, it is essential that the bridge be properly balanced during the launching and that the launching nose be constructed with a definite number and type of bays as explained in paragraph 89*b*.

b. SPECIAL METHODS. Site restrictions or other conditions may prevent the use of the normal method of launching. Part four of this manual gives the methods of launching required under these special conditions.

86. Methods of Construction

Single-story bridges are normally assembled and launched by manpower. They can be assembled complete on the rollers and launched or the bridge and nose can be pushed out over the gap after every two bays are constructed.

87. Working Parties

Working parties and construction times for various spans and types of panel bridges are given in chapter 8.

88. Capacity

The capacity of various spans and types of panel bridges is given in chapter 4.

Section II. LAUNCHING NOSE

89. Composition

a. GENERAL. The launching nose (fig. 70) consists of panels, transoms, rakers, sway braces, and when necessary, launching-nose links. It does not have stringers or decking. One transom with transom clamps and rakers is used behind the leading upright of each panel. Sway bracing is used in all but the first bay at the front of the launching nose. Footwalks are not built on the nose.

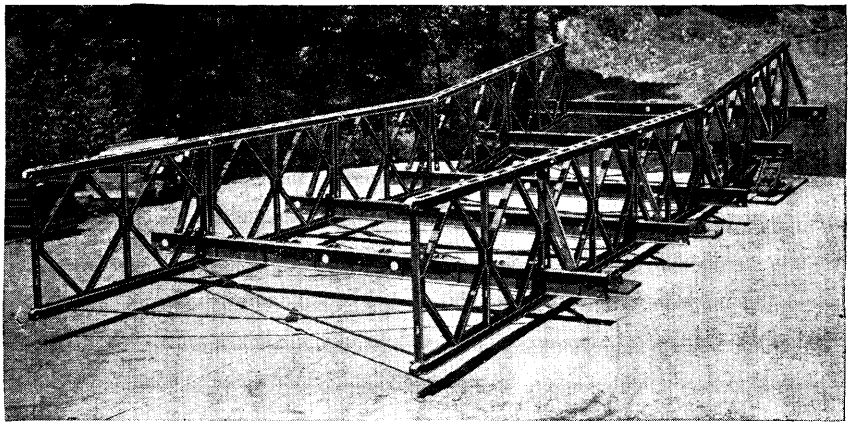
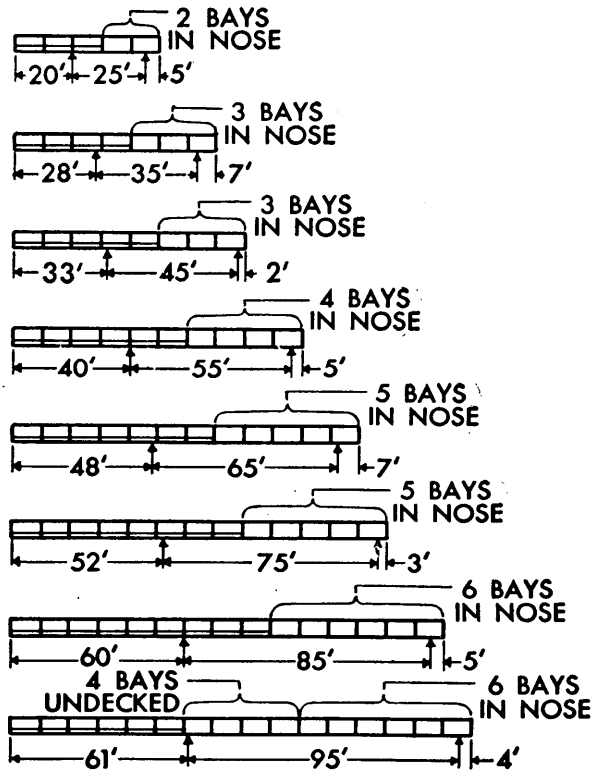


Figure 70. Launching nose.

b. CONSTRUCTION. The number and type of bays used in the nose depend on the span and the type of construction of the bridge. The composition of the launching nose for the various combination of span and bridge construction is given in tables 35 through 37. *These tables must be followed exactly with respect to the composition of the launching nose.*

Table 35. Construction for Launching Single-single Bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
30	11.0	3
40	14.5	4
50	17.5	5
60	21.0	8
70	25.0	12
80	27.5	15
90	31.5	25
100	28.5	33

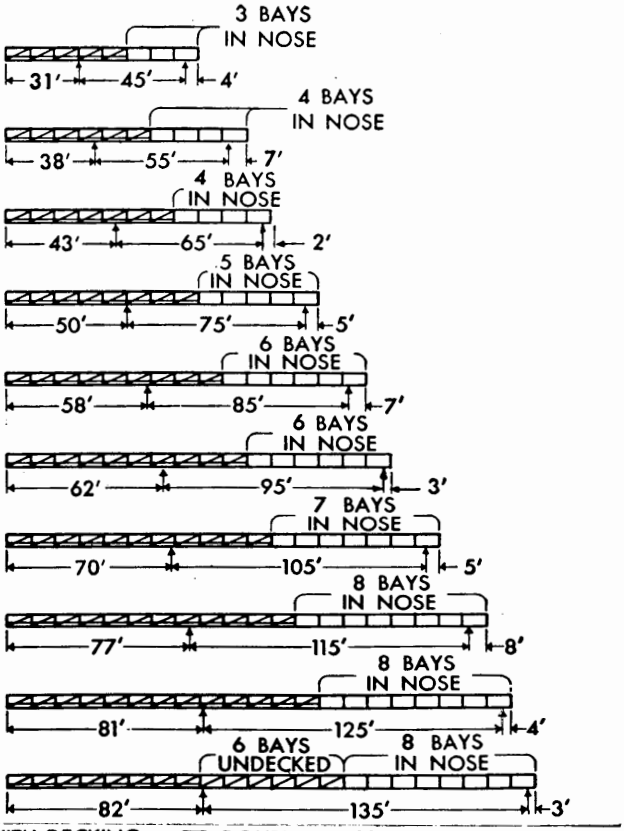


SINGLE TRUSS WITH DECKING

SINGLE TRUSS

Table 36. Construction for Launching Double-single Bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
50	20.5	4
60	25.0	7
70	28.5	9
80	33.0	14
90	37.0	20
100	40.5	23
110	45.0	33
120	49.5	45
130	53.0	52
140	47.5	63



DOUBLE TRUSS WITH DECKING DOUBLE TRUSS SINGLE TRUSS

Table 37. Construction for Launching Triple-single Bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)	
80	37.5	13	5 BAYS IN NOSE; 49′ — 75′ — 6′
90	42.5	19	6 BAYS IN NOSE; 56′ — 85′ — 9′
100	46.5	22	6 BAYS IN NOSE; 61′ — 95′ — 4′
110	51.5	30	7 BAYS IN NOSE; 68′ — 105′ — 7′
120	55.5	34	7 BAYS IN NOSE; 72′ — 115′ — 3′
130	60.5	47	8 BAYS IN NOSE; 79′ — 125′ — 6′
140	65.5	62	9 BAYS IN NOSE; 86′ — 135′ — 9′
150	60.5	70	6 BAYS UNDECKED; 9 BAYS IN NOSE; 87′ — 145′ — 8′
160	59.0	77	10 BAYS UNDECKED; 9 BAYS IN NOSE; 92′ — 155′ — 3′

TRIPLE TRUSS WITH DECKING TRIPLE TRUSS SINGLE TRUSS

90. Use of Launching-nose Links

a. General. The launching nose tends to sag as it is cantilevered over the gap. The approximate sag at the end of the nose just before it reaches the far bank is shown in tables 35 to 37. To overcome this sag, launching-nose links are used (fig. 71). Using one launching-nose link in each truss increases the length of the bottom chords of the launching nose by 7½ inches, thus raising the end of the launching nose by 13½ inches for each bay ahead of the links. Because links must not be inserted with more than four bays of the launching nose ahead of them, the maximum amount of lift that can be obtained from one pair of links is about 54 inches. If a greater amount of lift is required, an additional pair of links can be used in one of the joints between the original pair and the end of the nose, its place depending on how much lift is required. Table 38 gives the vertical lifts that can be obtained using one or more pairs of links. The maximum lift obtainable using launching-nose links is approximately 94½ inches.

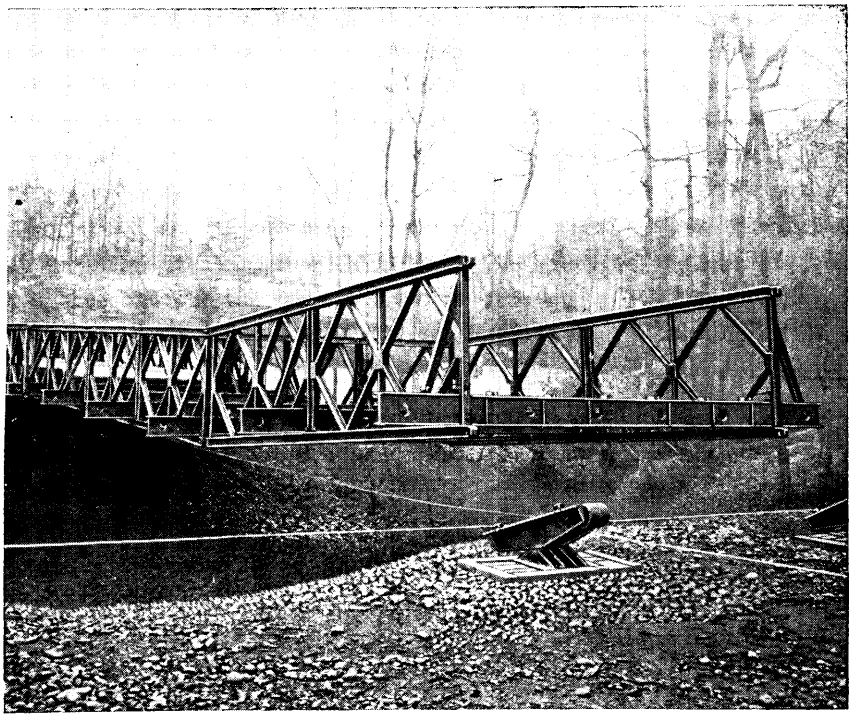


Figure 71. Upturned skeleton launching nose.

Table 38. Use of Launching-nose Links

Distance of links from tip of launching nose (feet)	Resulting vertical lift of tip of nose (inches)
One pair of links:	
10	13½
20	27
30	40½
40	54
Two pairs:	
10 and 40	67½
20 and 40	81
30 and 40	94½

b. FAR-BANK SEAT HIGHER THAN OR LEVEL WITH NEAR-BANK SEAT. When the far-bank seat is higher than or level with the near-bank seat, launching-nose links must be used to compensate for sag and the tops of all rollers must be in the same plane. If necessary, block and tackle should be used to prevent the bridge from sliding backwards.

c. FAR-BANK SEAT LOWER THAN NEAR-BANK SEAT. Launching-nose links are unnecessary if the far-bank seat is enough lower than the near-bank seat to take care of the sag. However, it is necessary to use block and tackle on the near bank to prevent the bridge from running away when the balance point passes the rocking rollers.

d. EXAMPLE OF THE USE OF LAUNCHING-NOSE LINKS.

Given:

A 160-foot TS bridge with an approximate sag of 77 inches at the tip of the launching nose (table 37). The far-bank seat is level with the near-bank seat.

Problem:

Are launching nose links required? If links are required what distance are they placed from tip of launching nose?

Solution:

Launching-nose links are required (see *b* above).

From table 38, it is found that where the sag at the tip of the launching nose is 77 inches, a pair of links must be used at 20 and 40 feet from tip of launching nose.

Section III. ASSEMBLY OF DOUBLE-SINGLE BRIDGE

91. General

Single-single bridge assembly is similar to double-single bridge assembly and is not described.

92. Nose

After the grillage, bearings, and launching rollers have been positioned, proceed with assembling and launching of nose as follows:

a. Place two panels (female end forward) on ground just back of rocking rollers. Clamp transom to panels behind forward uprights. Secure rakers to transom and panel with bracing bolts. Place a pair of plain rollers 2 inches below plane of tops of rollers and 12½ feet back of rocking rollers. These rollers are used as construction rollers and they also prevent the launching-nose links from fouling the ground. They are removed as soon as the links have passed over the rocking rollers. Raise rear of first panel onto plain rollers ((1), fig. 72).

b. Connect second bay ((2), fig. 72). Insert panel pins with points outward and with grooves in heads of pins horizontal. (See inner truss of fig. 78.) Clamp transom to panels behind forward uprights.

c. Place pair of sway braces in second bay (fig. 75).

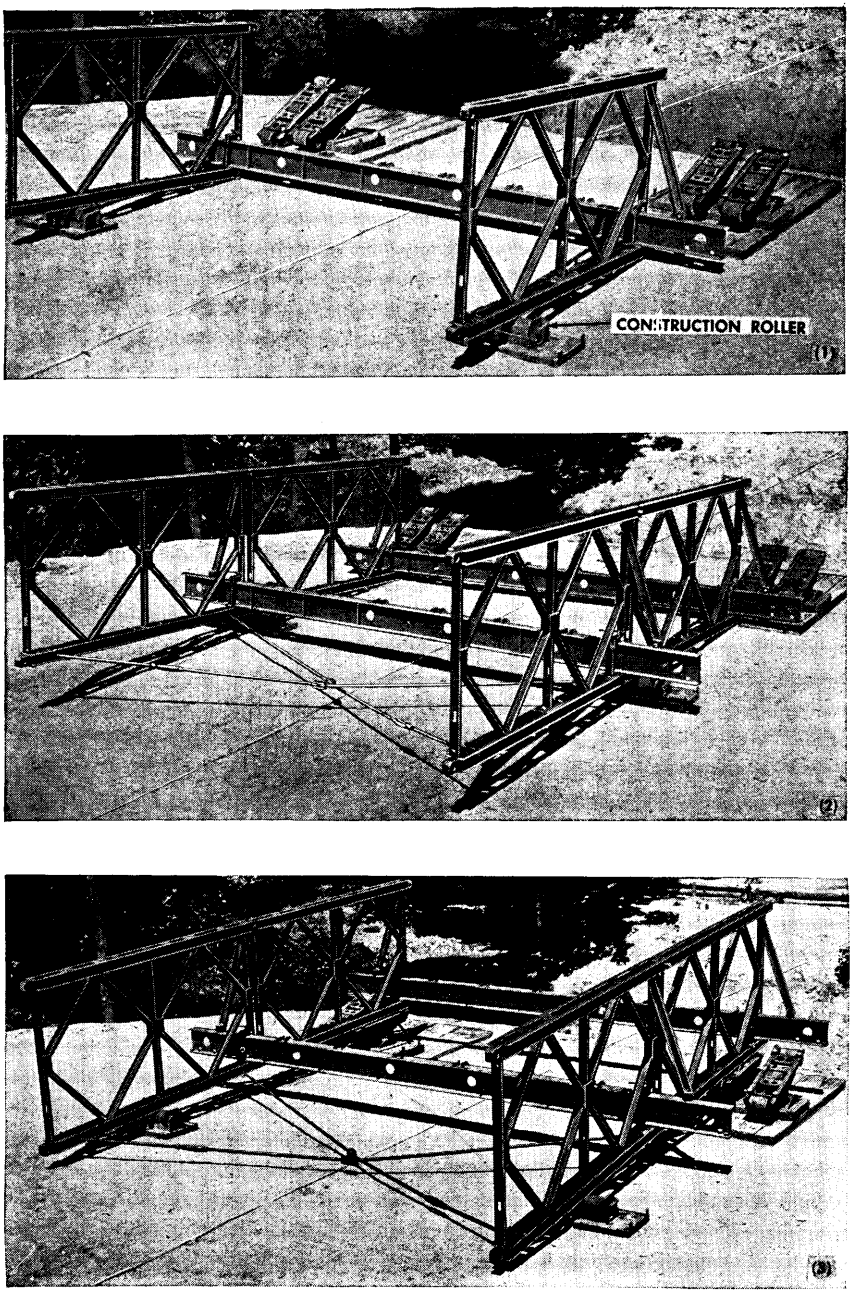


Figure 72. Assembly of launching nose.

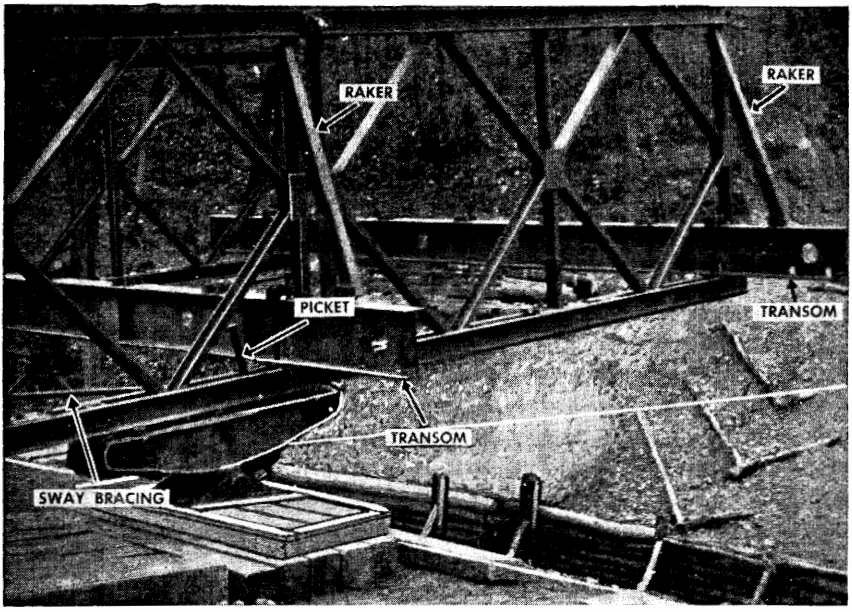


Figure 73. Front of launching nose with steel picket inserted in rollers to prevent movement.

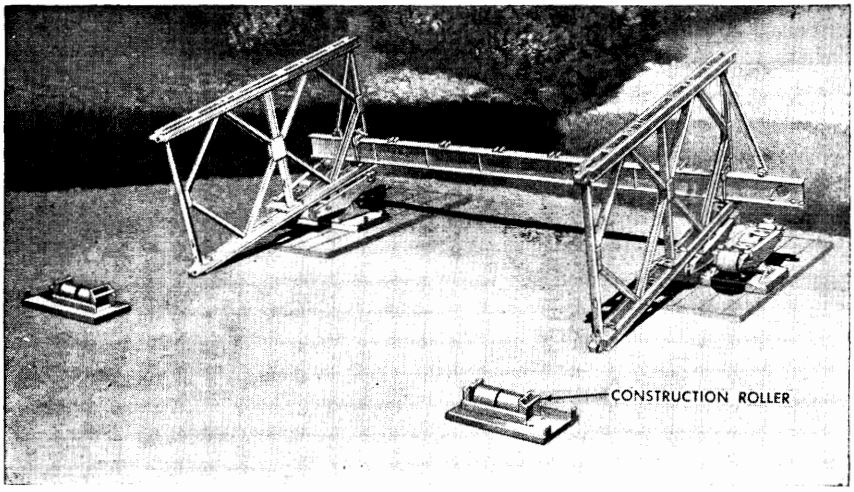


Figure 74. Alternate method for assembling launching nose when rocking rollers are on low cribbing.

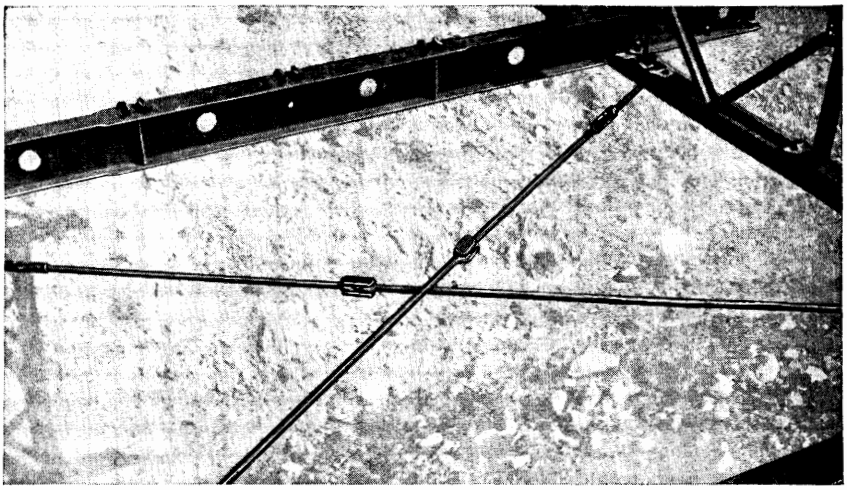


Figure 75. Sway braces in place in second bay of launching nose.

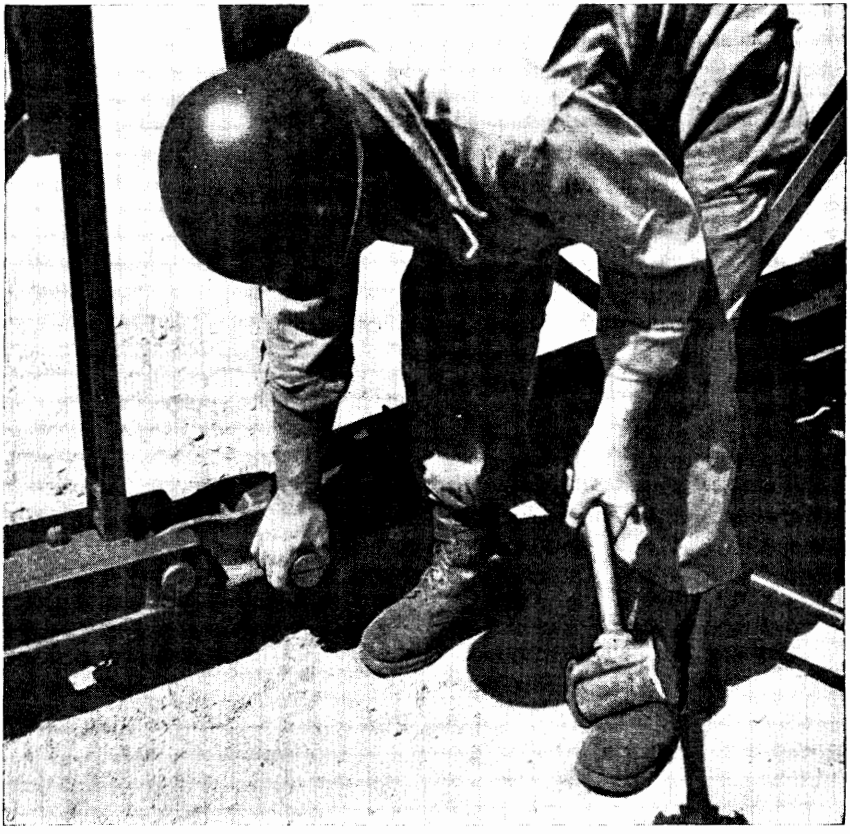


Figure 76. Inserting panel pin to connect panel in launching nose to launching-nose links.

d. Lift front end of assembled bays onto rocking rollers ((3), fig. 72) and secure with steel pickets through bottom chord of panels and rocking rollers (fig. 73). An alternate method (for rocking rollers on low cribbing) is as follows: Assemle first bay on ground. Lift front end of bay onto rocking rollers (fig. 74) and secure with steel pickets. Raise rear end and slide plain rollers under it 2 inches below plane of tops of rollers. This places plain rollers approximately 9 feet from rocking rollers. Add second bay.

e. If required, place launching-nose links in position between panels (fig. 76) as determined by erection conditions. See paragraph 90*d* to determine the number of links and their position in the nose.

f. Continue adding panels with transoms every 10 feet, sway braces in every bay, and rakers on every transom until enough skeleton nose has been built. For lengths of nose required for various spans, see tables 35 to 37, inclusive.

93. First Bay of Bridge

When construction of nose is completed, assemble first bay of bridge as follows:

a. Connect first two panels of inner truss with last bay of nose ((1), fig. 77). Insert panel pins with points outward and grooves in heads of pins horizontal. Insert first transom in front of middle vertical and clamp loosely with transom clamps.

b. Add panels of outer truss in first bay and hold in place with transom clamps ((2), fig. 77).

c. Insert second transom in *front* of rear vertical and third transom *behind* front vertical. Clamp loosely. Fix rakers to second transom and sway braces and bracing frames in first bay loosely ((3), fig. 77). Sway braces are positioned with short ends pinned to same side of bridge so both turnbuckles are under one stringer. *All sway braces, transom clamps, bracing frames, rakers, and tie plates in one bay should be left loose until all parts except stringers and decking are fitted for the next bay being assembled.*

d. Add second bay of panels ((4), fig. 77). Place outer truss first with panel pins pointing inward and inner truss next with panel pins pointing outward (fig. 78). The reason for the order of placement of panel and panel pins will become apparent when triple truss bridges are constructed. It is best to use the same order of assembly for both types of constructions.

e. Place a chess on top of transom behind front vertical in first bay and position stringers for first bay ((5), fig. 77 and fig. 79). Leave stringer over sway brace turnbuckles on edge until sway braces have been tightened (fig. 80). After bridge has been launched and when

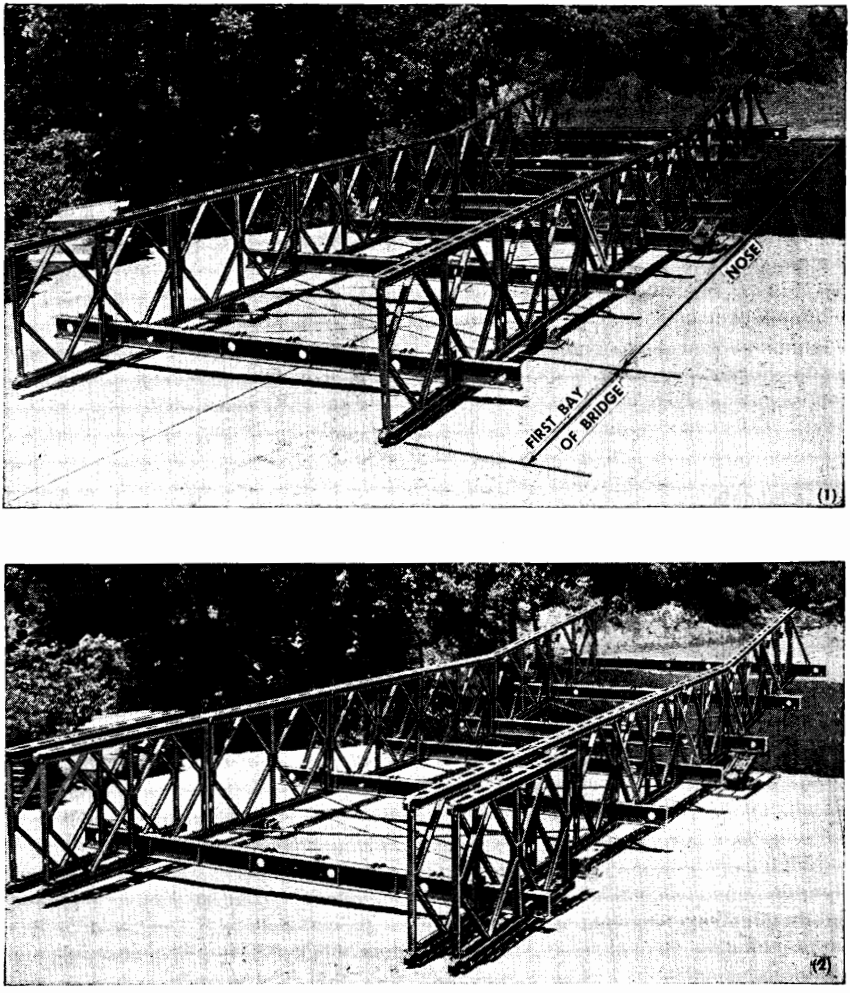


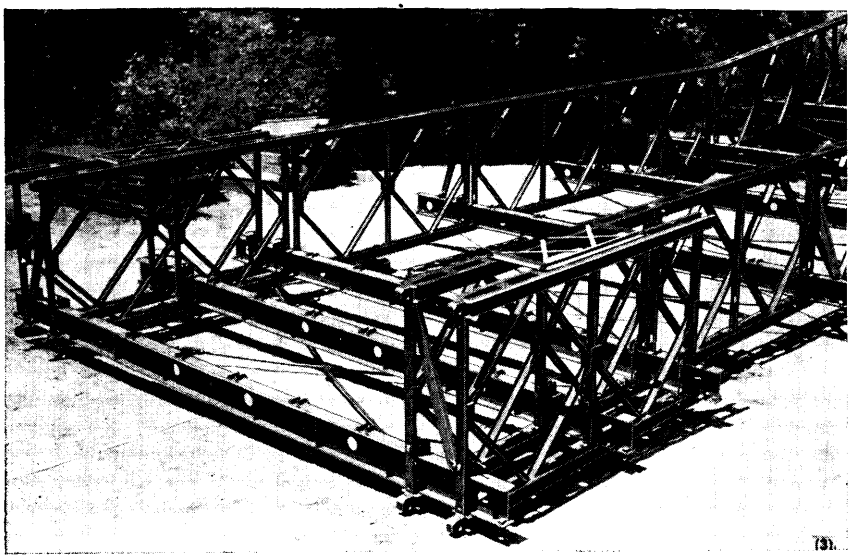
Figure 77. Assembly of first bay of DS bridge.

end-post transom is inserted, the chess holding up the stringers and decking in the first bay can be pushed clear with crowbars, and decking will drop into position.

f. Position panels of third bay and at the same time insert transoms in second bay, one in front of middle vertical and one in front of rear vertical ((6), fig. 77).

g. After transoms are in position in second bay, fix sway braces, rakers, and bracing frames loosely ((7), fig. 77). Install rakers only on transoms at end verticals.

h. Tighten bracing in first bay, and deck first bay ((8), fig. 77).



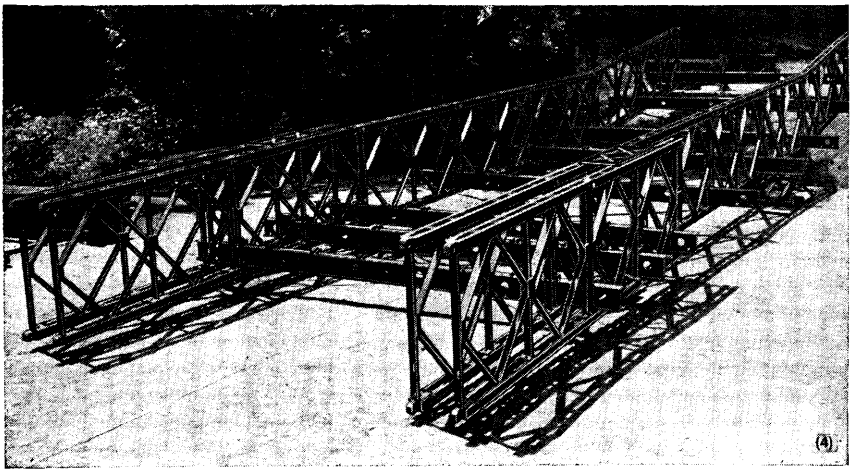


Figure 77. Assembly of first bay of DS bridge—Continued.

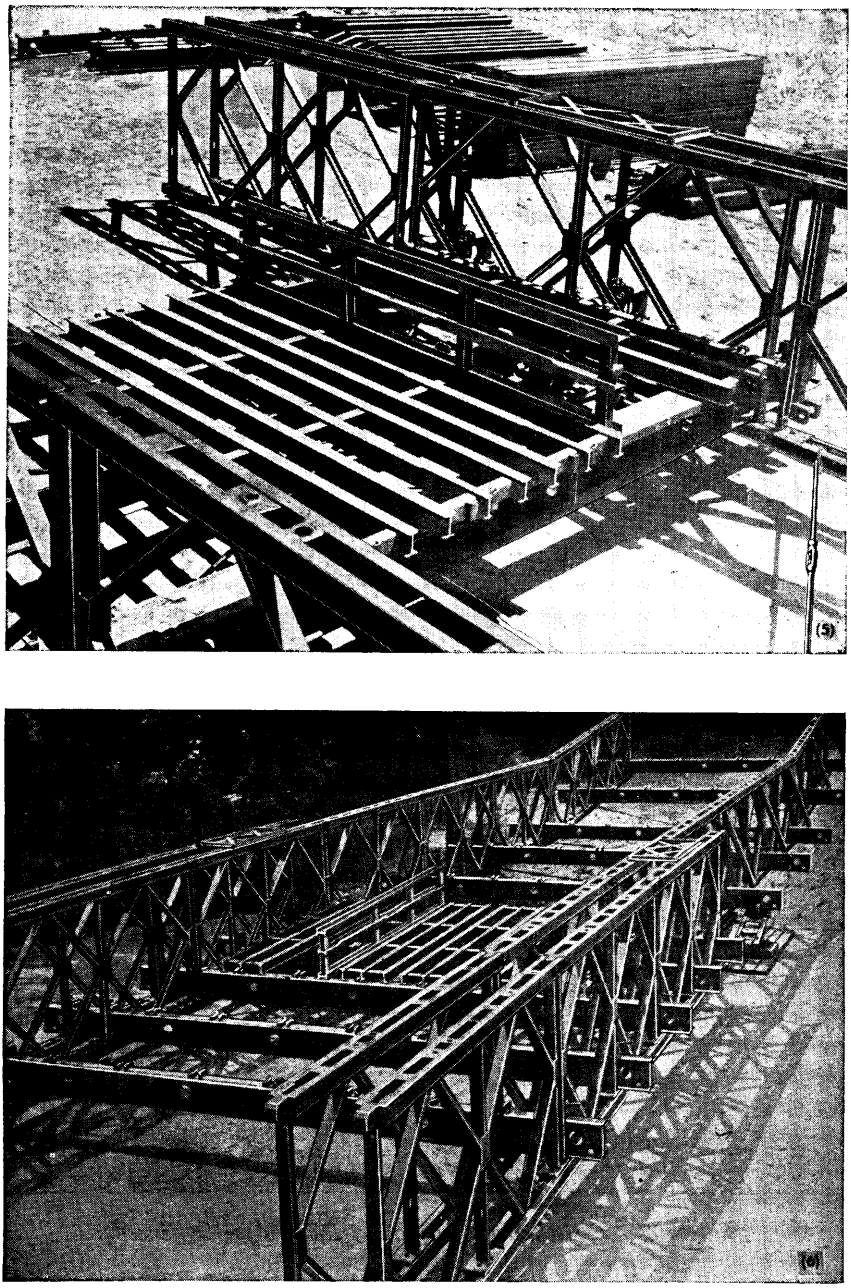
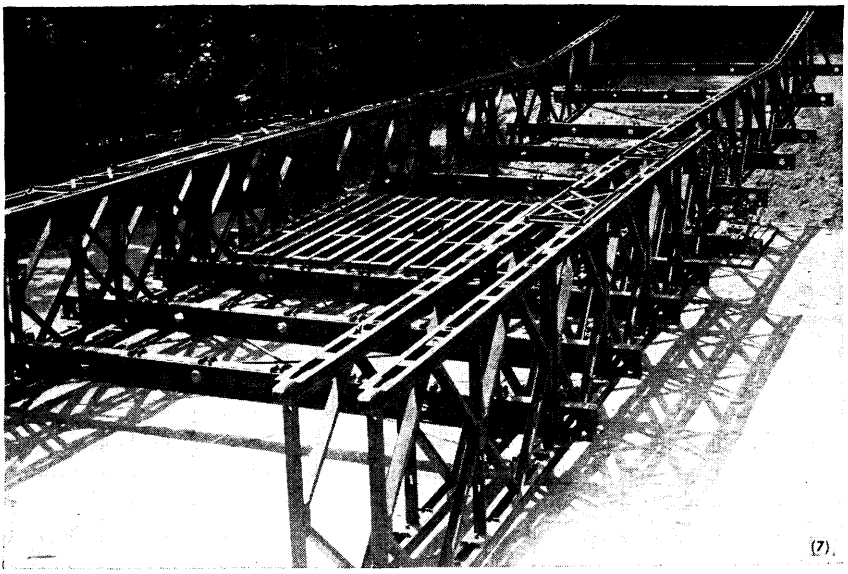


Figure 77. Assembly of first bay of DS bridge—Continued.



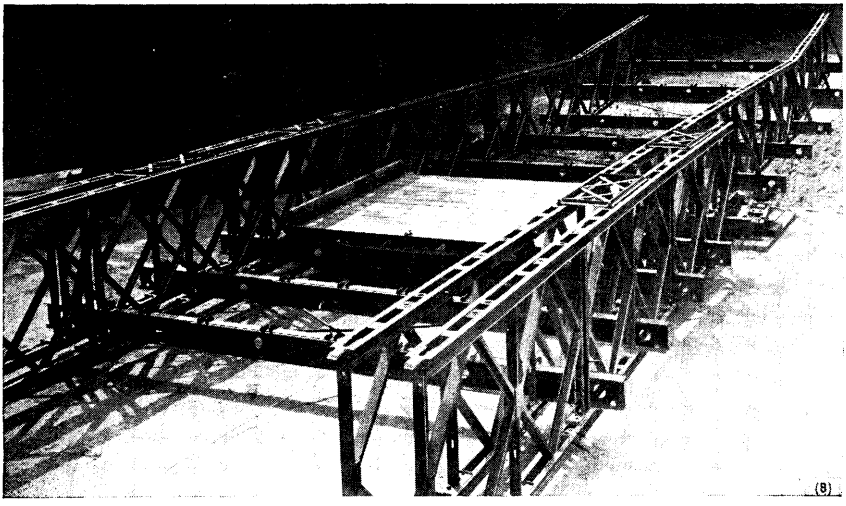


Figure 77. Assembly of first bay of DS bridge—Continued.

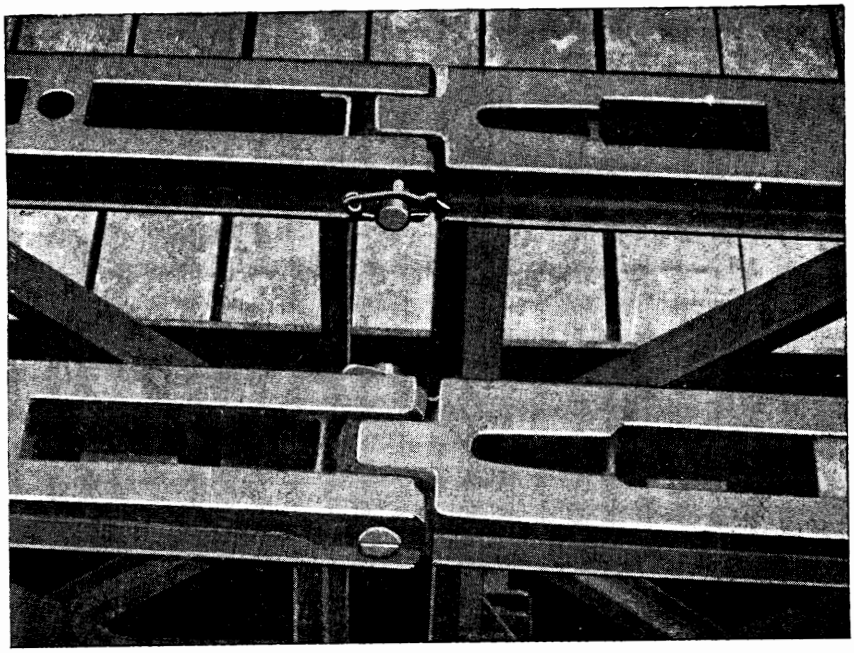


Figure 78. Position of panel pins in DS bridge.

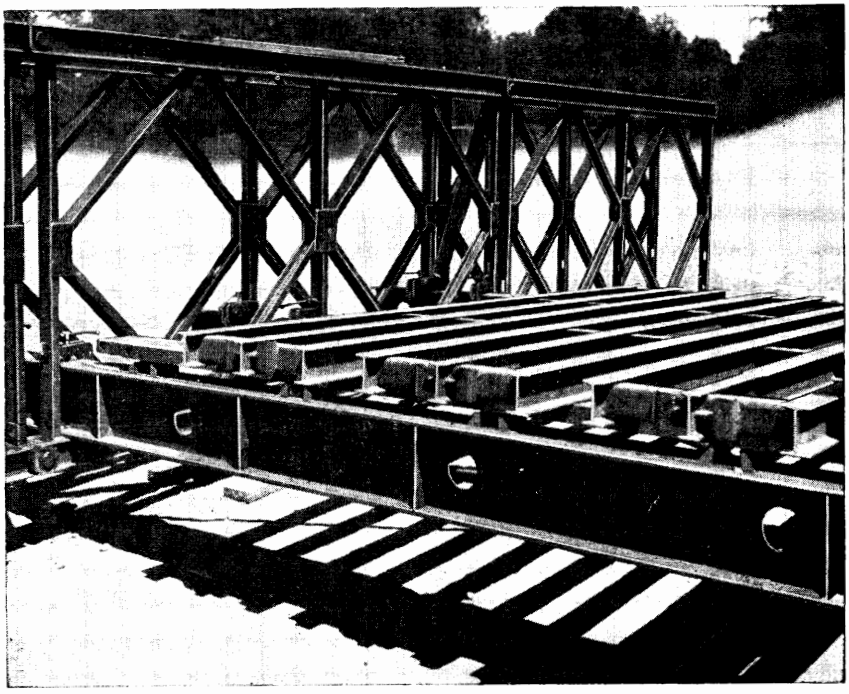


Figure 79. Construction transom with chess behind front vertical of first bay to allow insertion of transom in end post after bridge has been launched.



Figure 80. Stringer over sway-brace turnbuckle laid on edge to provide room for tightening sway braces. Sway braces in one bay are left loose until bracing is fitted for next bay being assembled.

94. Remainder of Bridge

a. Position stringers in second bay and leave stringer over sway brace turnbuckles on edge until sway braces have been tightened ((1), fig. 81).

b. Add fourth bay of panels and at same time insert transoms in third bay ((2), fig. 81).

c. Add bracing in third bay. Tighten bracing in second bay, and deck second bay ((3), fig. 81).

d. The sequence is complete. The same sequence is used for rest of bridge. All jobs proceed at the same time and the sequence is used to prevent crowding of assembly and carrying parties.

e. Normally, footwalks are not used. However, when time, men, and materials are available, footwalks can be built. Footwalks should be erected before launching because it is awkward to place bearers and footwalks after bridge is in place. Bearers are attached to all transoms. They fit over and under special lugs welded to transom. Footwalks are positioned by lugs on bearers (fig. 16). Footwalk posts are inserted in sockets at ends of bearers and hand ropes threaded through eyes of posts. Figure 82 shows completed footwalk.

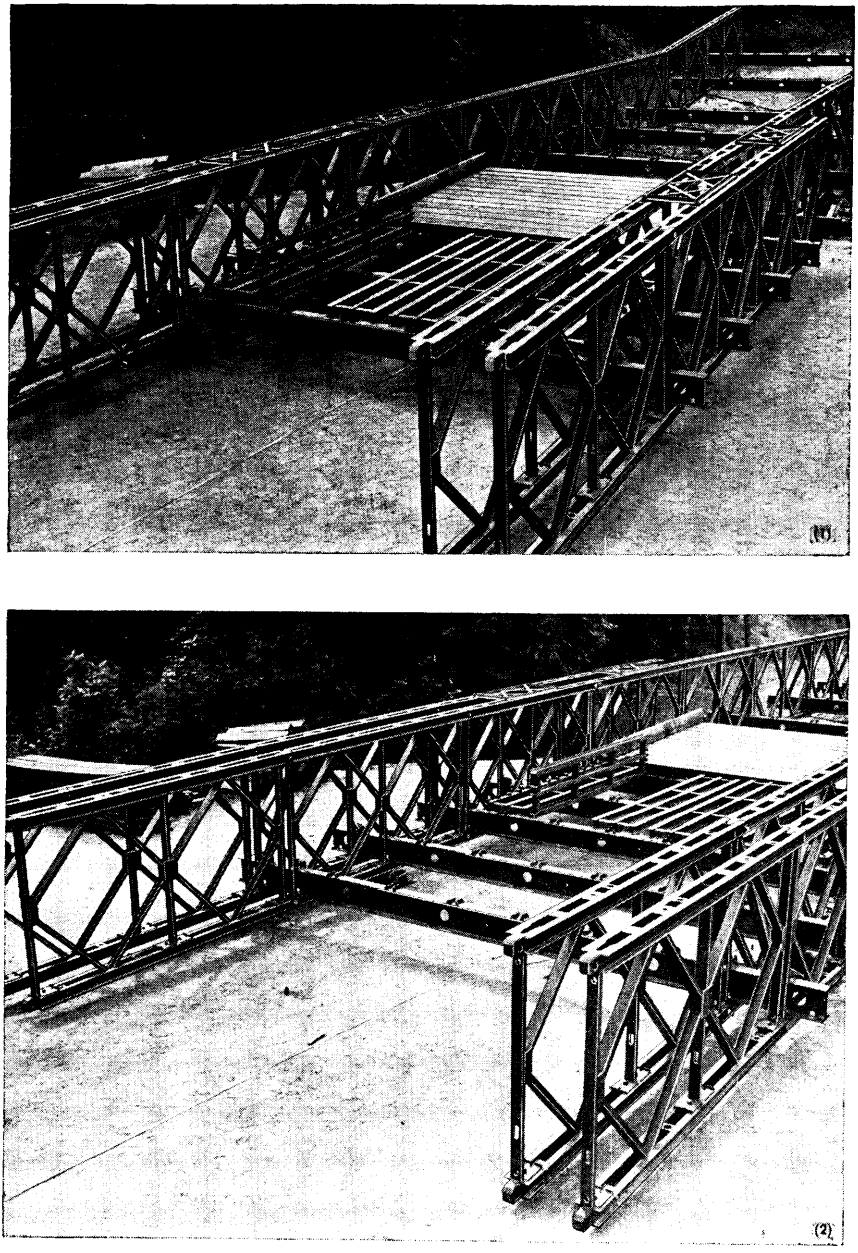


Figure 81. Assembly of remainder of DS bridge.

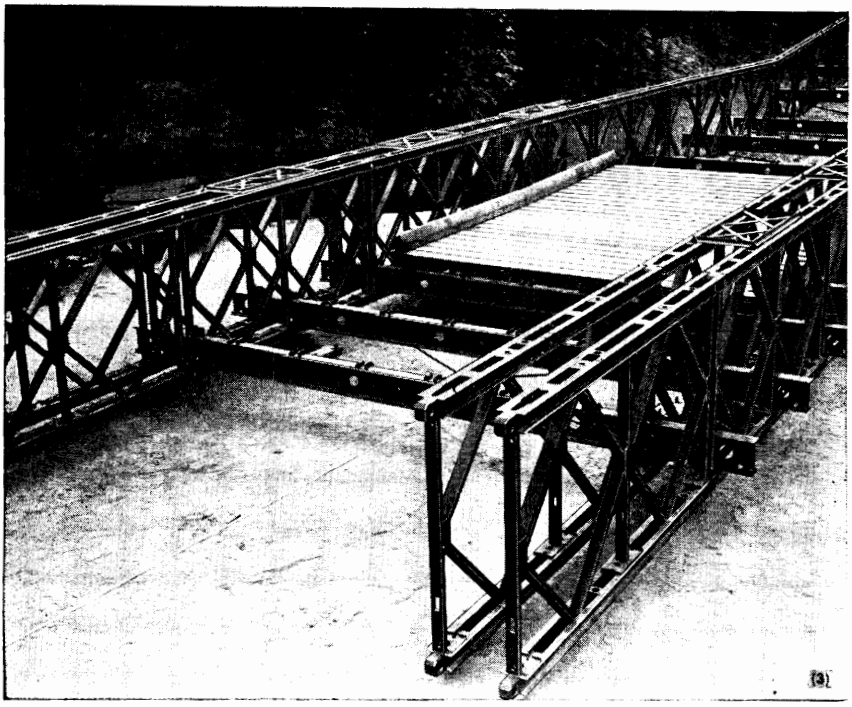


Figure 81. Assembly of remainder of DS bridge—Continued.

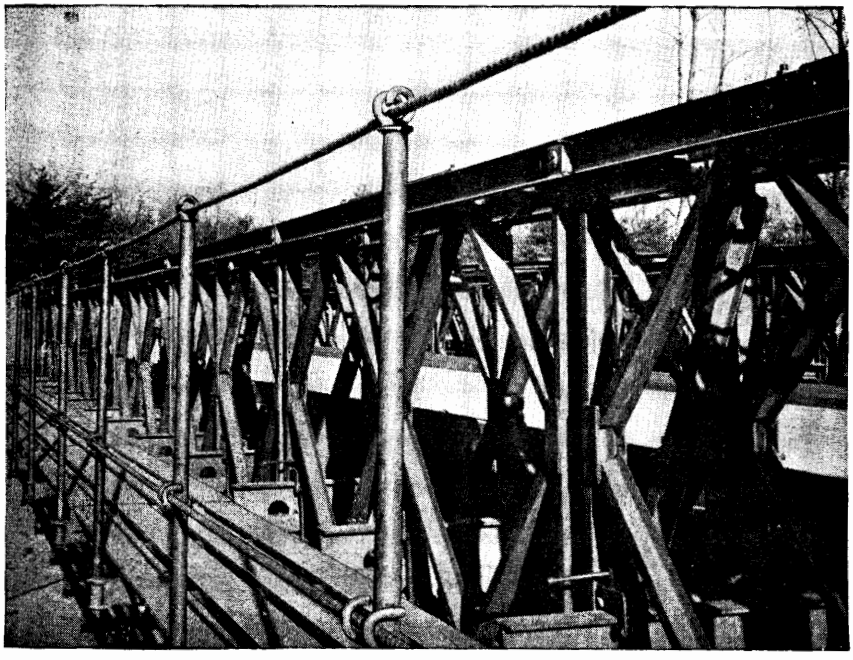


Figure 82. Completed footwalk.

Section IV. ASSEMBLY OF TRIPLE-SINGLE BRIDGE

95. General

The method of assembly for the triple-single bridge is similar to that for the double-single. Assembly of outer truss must lag one bay, however, so panel pins in second truss can be inserted. In addition, short pins must be used in the middle and outer truss end posts because normal length pins will not fit.

96. Nose

The assembly of launching nose for TS bridges is the same as the assembly of launching nose for DS bridges

97. First Bay of Bridge

Assemble first bay of bridge as follows:

a. Connect first two panels of inner truss with last bay of nose. Insert first transom in front of middle vertical and clamp loosely with transom clamp ((1), fig. 83).

b. Add panels of middle truss in first bay and hold in place with transom clamps ((2), fig. 83).

c. Insert second transom in front of rear vertical. Attach rakers and position bracing frames and sway braces ((3), fig. 83). Construction transom behind front vertical is omitted until the outer truss in the first bay has been positioned.

d. Add middle truss panels in second bay ((4), fig. 83). This panel must be positioned before the outer truss panel in the first bay so panel pins can be inserted.

e. Add outer truss panels to first bay. Position construction transom behind forward uprights in first bay. Add inner truss panels to second bay ((5), fig. 83).

f. Place chess on construction transom and position stringers in first bay ((6), fig. 83).

g. Position middle truss panels in third bay and at same time insert transoms in second bay, one in front of middle vertical and one in front of end vertical ((7), fig. 83).

h. Add bracing in second bay. Tighten bracing in first bay and deck first bay ((8), fig. 83).

98. Remainder of Bridge

a. Position outer truss of second bay and connect to middle truss with tie plates bolted to top raker holes in forward uprights of panels (fig. 84). Add inner truss of third bay ((1), fig. 85). Figure 86 shows the position of panel pins in TS bridge.

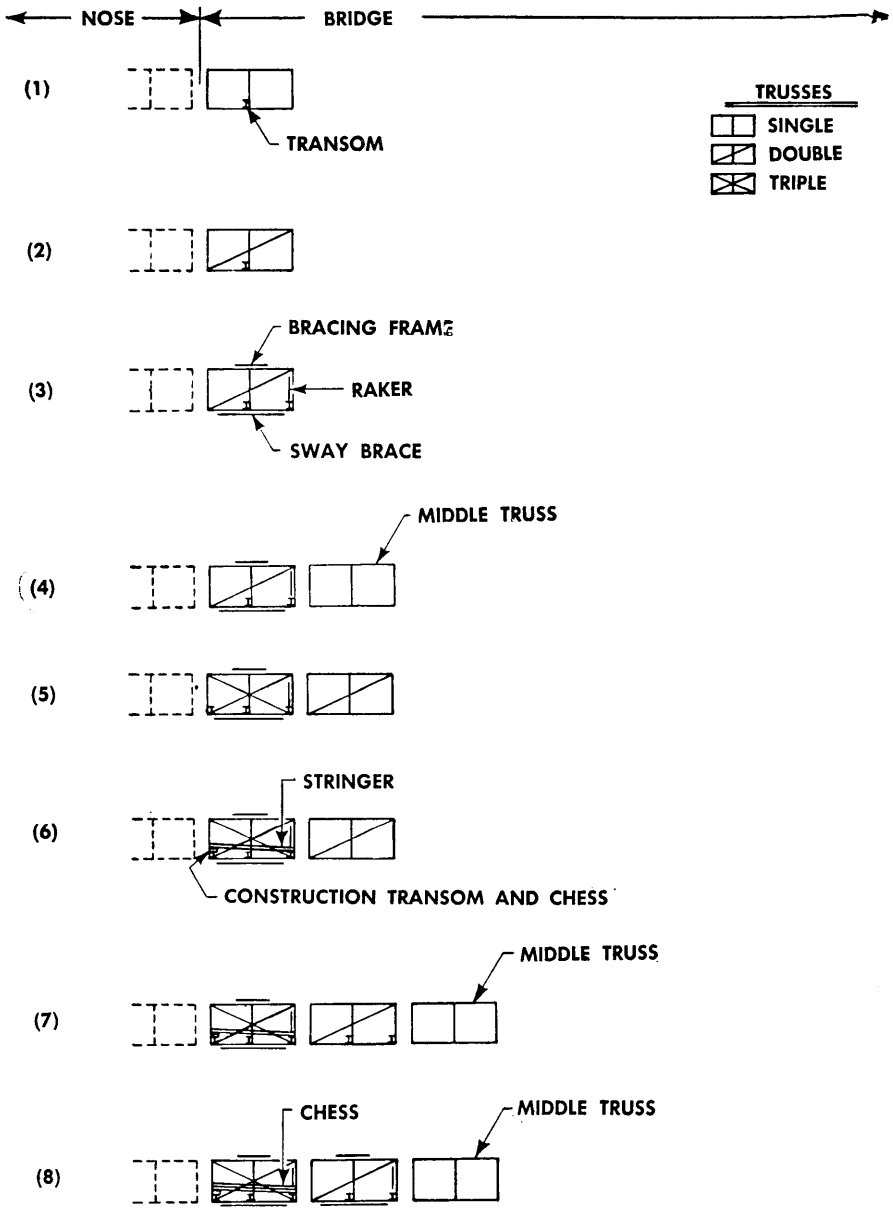


Figure 83. Assembly of first bay of triple-single bridge.

b. Place stringers in second bay. Position middle truss panels in fourth bay and at same time insert transoms in third bay ((2), fig. 85).

c. Add bracing in third bay. Tighten bracing in second bay and deck second bay ((3), fig. 85).

d. The sequence is complete and the same sequence is used for the rest of bridge.

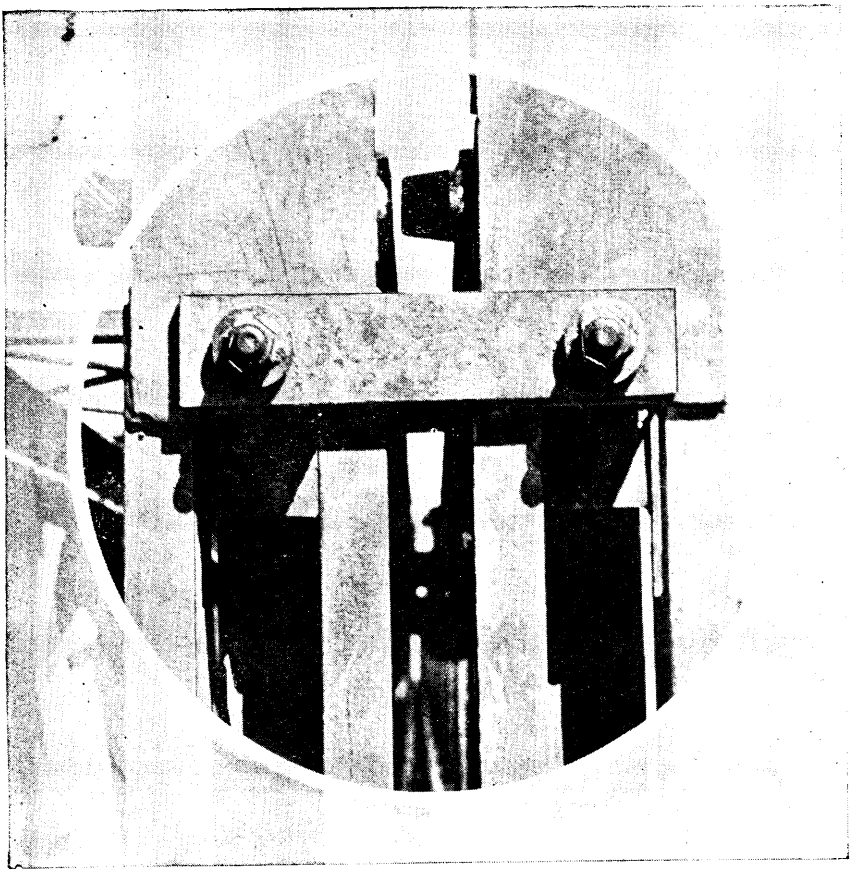


Figure 84. Tie plate between middle and outer trusses in triple-single bridge.

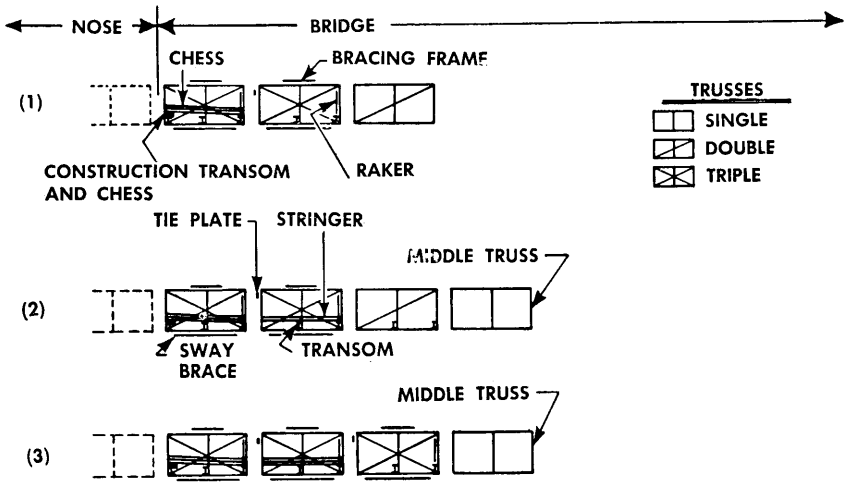
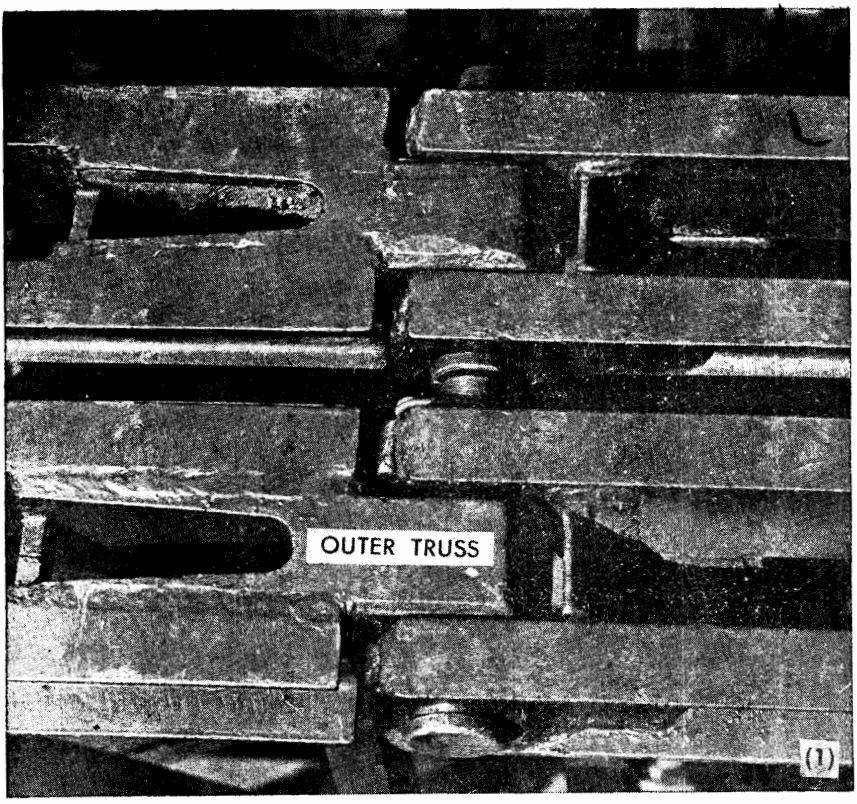
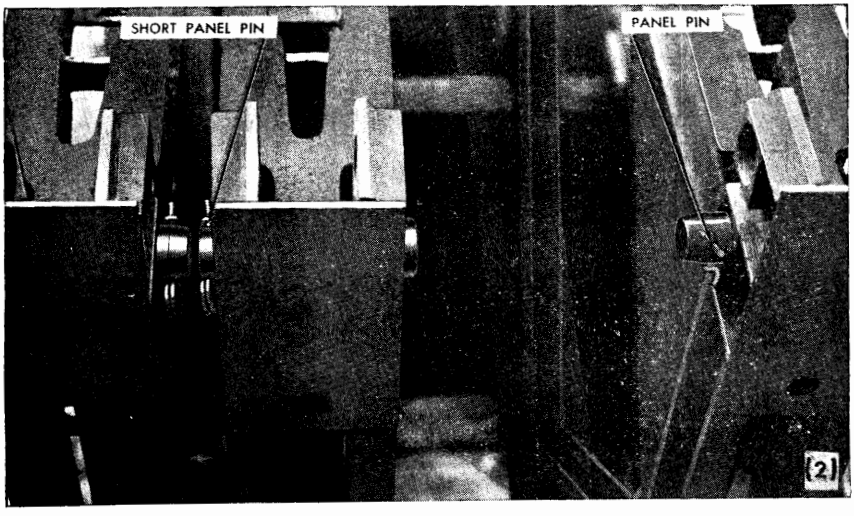


Figure 85. Assembly of remainder of triple-single bridge.



①*Pins in main part of bridge.*



②*Use of short panel pins in end posts.*

Figure 86. Position of panel pins in triple-single bridge.

Section V. LAUNCHING AND JACKING DOWN

99. Launching

a. GENERAL. (1) Single story bridges are normally assembled and launched by manpower. They can be assembled complete on the rollers and launched or the bridge and nose can be pushed out over the gap after every two bays are constructed. Pickets are inserted after each move to prevent rolling (fig. 73

(2) During launching the entire bridge including nose must be counterbalanced so the structure does not tip into gap. The counterbalance is normally accomplished by adding sufficient bridge behind the near-shore rocking rollers to act as a counterweight and keep the balance point between the plain rollers and the rocking rollers. This condition must prevail until the launching nose reaches the rollers on the far bank. This point is illustrated in tables 35 to 37 which show the bridge and launching nose just spanning the gap; in this position the bridge is completely assembled and the balance point is slightly behind the near-shore rocking rollers. As the bridge is pushed on across the gap from this position, the balance point passes the rocking rollers. The part of the bridge acting as a counterweight is no longer needed to maintain balance because there is now no danger of tipping into the gap; however, *it is needed to avoid excess stress in the launching nose until launching is completed.* Dismantling any of the bridge behind the rocking rollers will throw additional stress on the launching nose and on the part of the bridge which is across the gap; this may result in failure of the nose.

Caution: The near-bank rocking rollers and the far-bank rocking rollers must carry the entire load after the launching nose reaches the far-bank rocking rollers (fig. 87). The launching nose may fail if the near-bank plain rollers are permitted to carry any load after the nose reaches the far-bank rocking rollers. The rear of the bridge must hang free to act as a counterweight. This is done by cribbing up near-bank rocking rollers, or removing plain rollers so rear end of bridge does not rest on them after launching nose reaches far-bank rocking rollers. If removal of plain rollers is not enough, excavate ground to give necessary clearance.

b. COMPLETION OF ASSEMBLY AND LAUNCHING. After the nose and the first bay of bridge have been completed, proceed with launching as follows:

(1) One pair of plain rollers has been placed 25 feet behind rocking rollers. Additional plain rollers are not required when launching bridges up to 80 feet long. Bridges over 80 feet long require additional sets of plain rollers spaced at 25-foot intervals. Bridges are built on the

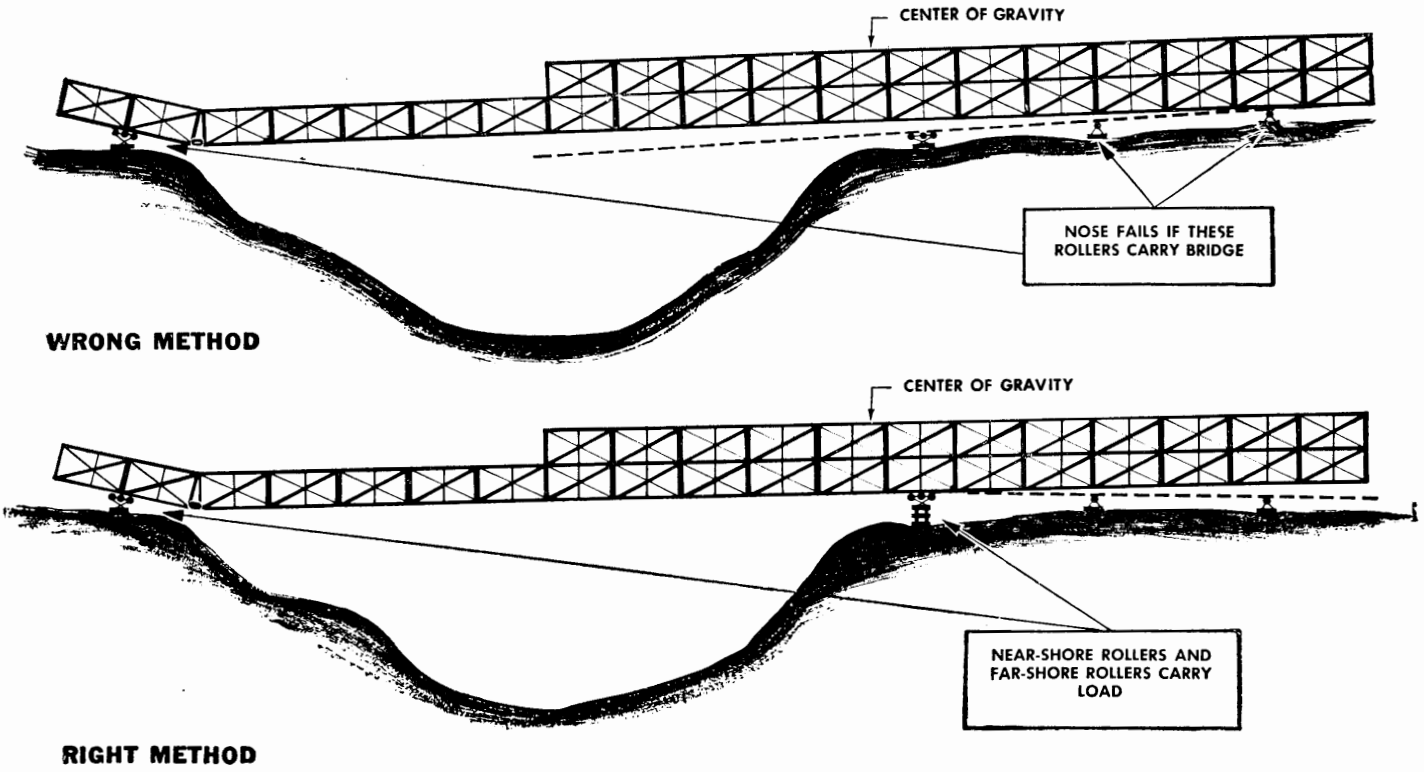


Figure 87. Position of rollers. Once launching nose rests on far-bank rocking rollers, bridge must clear near-bank plain rollers and must remain clear of them.

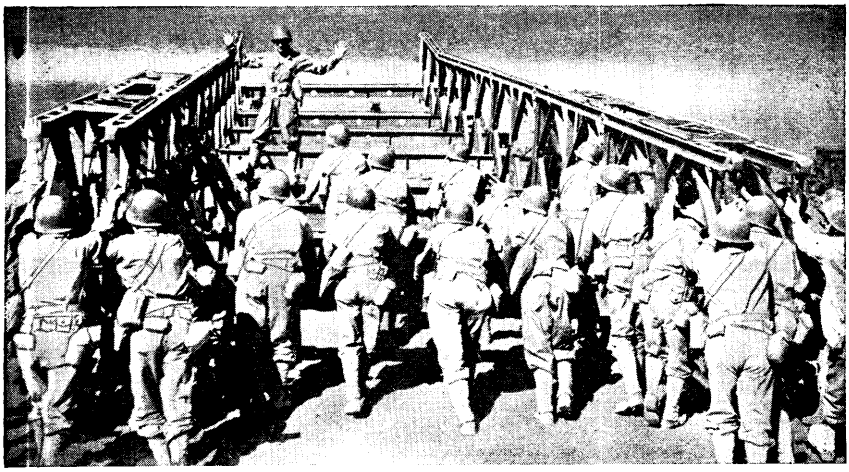


Figure 88. Pushing launching nose over gap after completion of first two bays of bridge.

rollers and when necessary jacks are used to aid insertion of lower panel pins of panels resting on rollers.

(2) Continue building bridge and rolling out on rollers (fig. 88). When forward end of the launching nose reaches the rollers on the far bank (fig. 89), a detail guides it onto the rollers (fig. 90) and dismantles it bay by bay (fig. 91).

(3) When the end of the bridge proper clears the rollers on the far bank, attach the near-bank end posts. At the same time, attach the far-bank end posts and lay a transom across their steps. Middle and

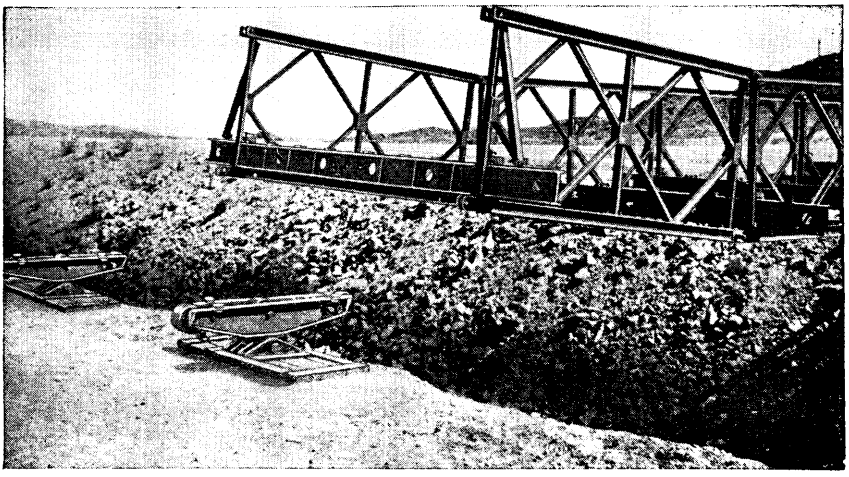


Figure 89. Launching nose approaching far bank; rocking rollers in place.

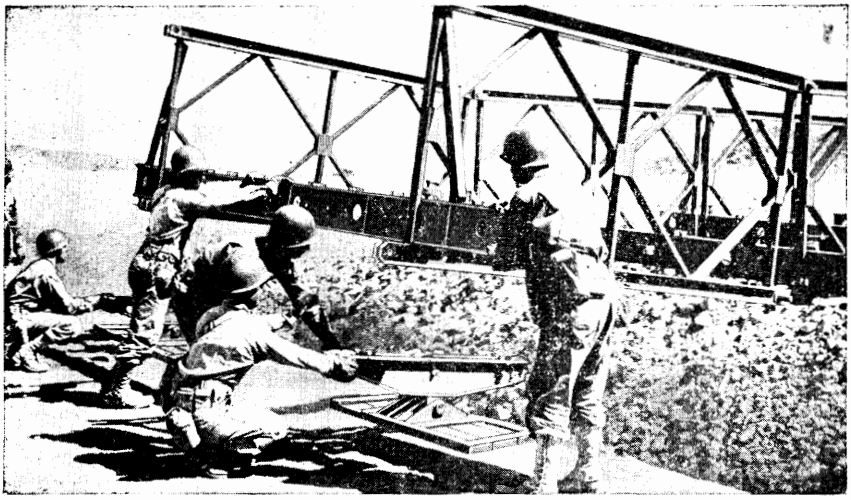


Figure 90. Guiding launching nose onto rocking rollers.

outer truss end posts on triple truss bridge are pinned with short panel pins and tied together with tie plates in the raker holes. Pins in middle truss end posts are inserted with points outward and in outer truss end posts with points inward (fig. 86). Normal pins and methods of pinning are used on the inner truss end posts. Remove construction chess behind the front vertical in the first bay so decking drops into place.

c. PRECAUTIONS. (1) *Do not use bent or distorted parts.*

(2) *Do not attempt to convert the launching nose into bridge by adding parts to it.*

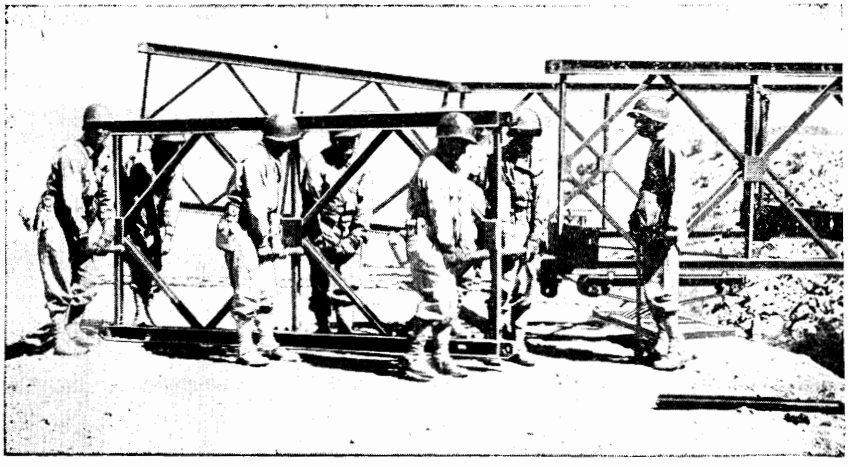


Figure 91. Dismantling launching nose.

(3) *In launching bridge over rollers, keep the center of gravity behind the rocking rollers until the launching nose reaches the far bank. Thereafter, do not dismantle the bridge behind the near-bank rocking rollers or remove the counterweight until all of the launching nose has cleared the far-bank rocking rollers.*

(4) *After the launching nose passes over the far-bank rocking rollers, always make certain the weight of the bridge is carried only by the near-bank rocking rollers and the far-bank rocking rollers.*

100. Jacking Down

a. PROCEDURE. After the end posts and end transom have been installed, proceed with jacking down as follows:

(1) Place jack shoe on base plate and jacks on shoes with toes of jacks under steps of end posts (fig. 92). At each corner of the bridge, use enough jacks so that one jack carries no more than 7½ tons on the toe or 15 tons on top. Jacks must be operated in unison so the load is distributed evenly between them to prevent failure of jacks. *Pitch of teeth may vary in jacks of different manufacture. Jacks used together must always have the same pitch.*

(2) Jack up the ends of the bridge successively and remove the rocking rollers (fig. 93). Place bearings on base plate as shown in figure 14.

(3) Lower bridge in stages (figs. 94 and 95). Place grillage under the bottom chord of the trusses to catch the bridge if it slips off the jacks. It does not matter which end of the bridge is lowered first, but the jacks must be operated in unison and *only on one end at a time.*

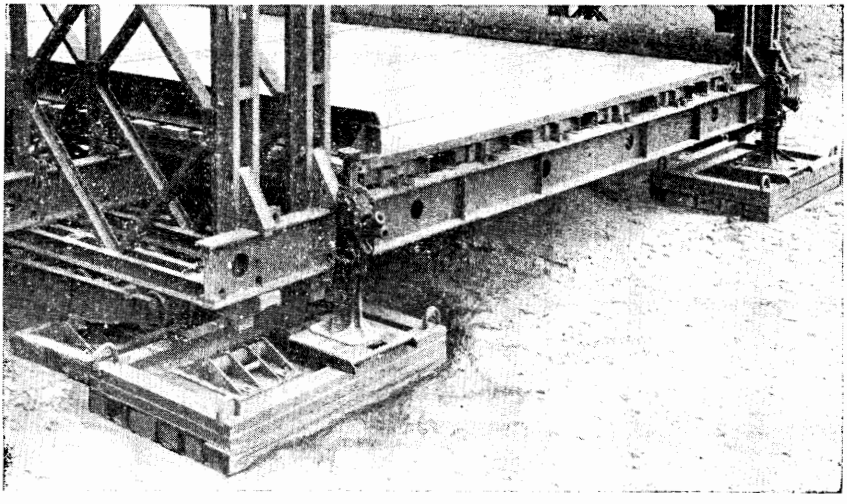


Figure 92. Jacks in place before jacking end of bridge off rocking rollers.

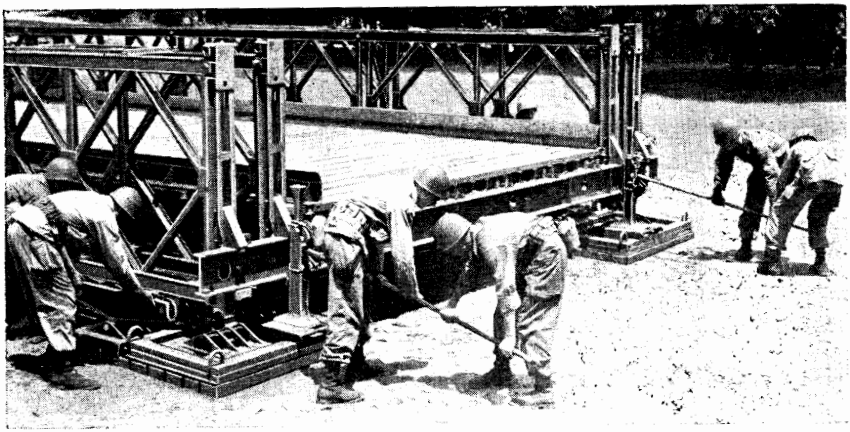


Figure 93. Jacking up end of bridge before removal of rocking rollers.

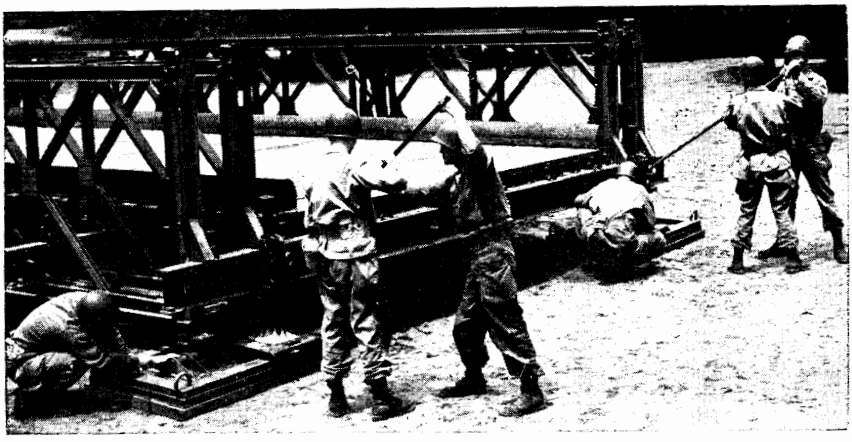


Figure 94. Jacking down end of bridge on bearings.

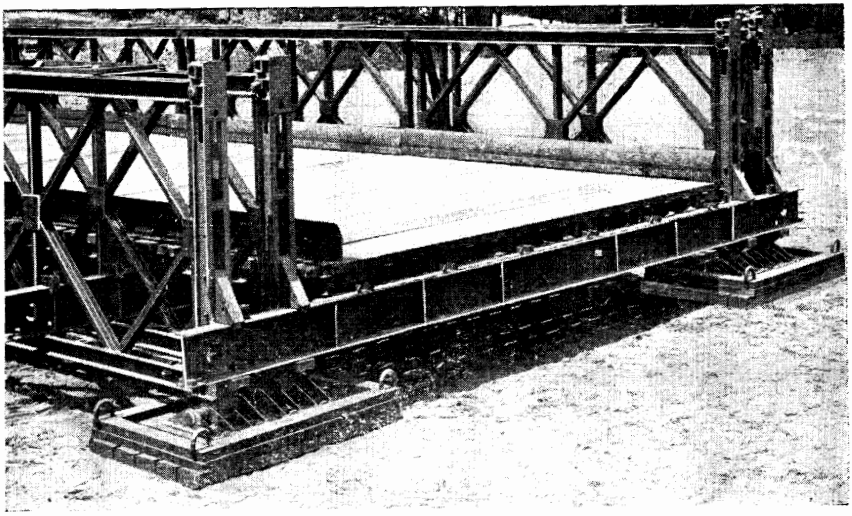


Figure 95. End of bridge jacked down on bearings.

Section VI. RAMPS

101. General

Before placing ramps, the end transoms of the bridge must be cribbed if the bridge is to carry loads of 39 tons or more. (See par. 82.) Ramps must be cribbed and wedged at midpoint for loads of 45 tons or more. (See par. 81.) Cribbing and wedges must be properly drift-pinned or nailed to prevent shifting under traffic. If slope of ramp is not over 10 to 1, only one bay of ramp is necessary (fig. 96). When two bays are needed, they are supported at their junction by a transom which is supported by four ramp pedestals resting on the ground or grillage (fig. 68). Ramp bays are decked in the same way as bays of the bridge proper.

102. Assembly

After end transoms of bridge are cribbed (if necessary) proceed with assembly of ramp as follows:

a. Position sill for end of ramp as described in paragraph 81*a*. If ramp is to be two-bay ramp, position ramp pedestals and transom (figs. 68 and 15).

b. Position rams and add decking (figs. 96 and 97).

c. Grade approach to ramps and the bridge is complete.

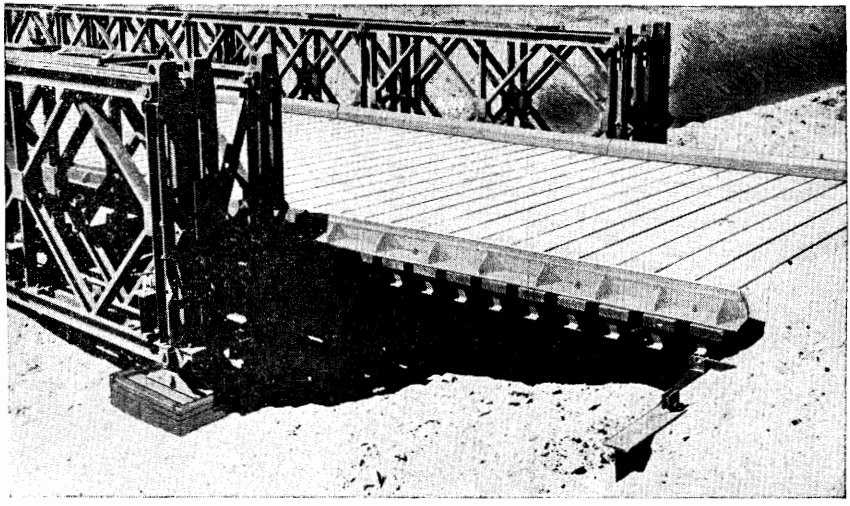


Figure 96. Single-bay ramp completely decked.

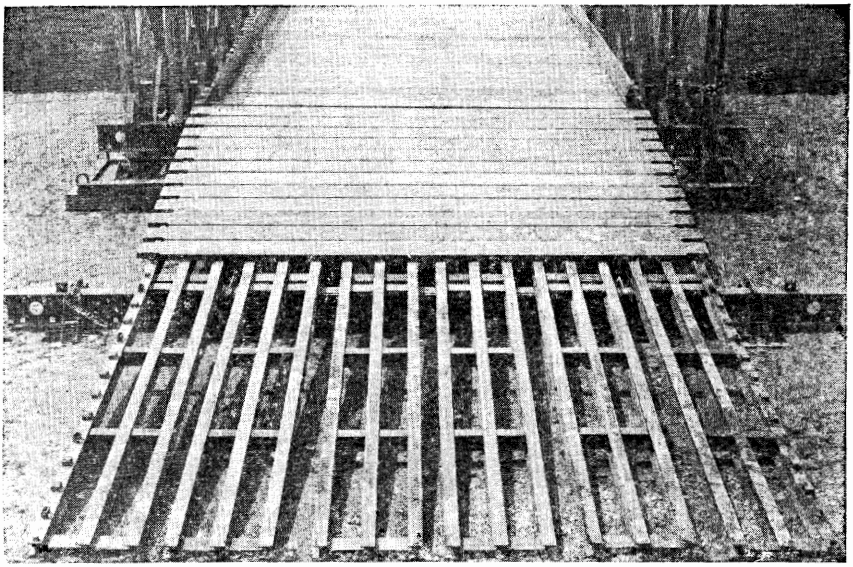


Figure 97. Two-bay ramp with chess laid on first bay.

Section VII. REINFORCING BRIDGE

103. General

The load capacity of existing single- and double-truss bridges can be increased by the addition of extra trusses. Construction starts from the center of the bridge and panels are added toward each end. Panel levers are used to aid in positioning the extra panels.

104. Converting Single-Single to Double-Single

To convert an existing SS bridge to a DS bridge, proceed as follows:

a. Remove footwalk (if any).

b. Place first panel on top chord at center of bridge. (See fig. 98.)

c. Lower panel over side with rope slings at ends of panel and position with levers. (See fig. 99.)

d. Insert transom clamps and tighten. Tightening transom clamps helps reduce difficulty caused by sag.

e. Position second panel, insert transom clamps and tighten. Insert panel pins (point inward) first in bottom and then in top of panel (See fig. 99.)

f. Connect outer truss to first with bracing frames bolted to top chord. Continue adding panels toward each end of bridge.

g. Jack bridge off bearings (ramps need not be removed) and install end posts.

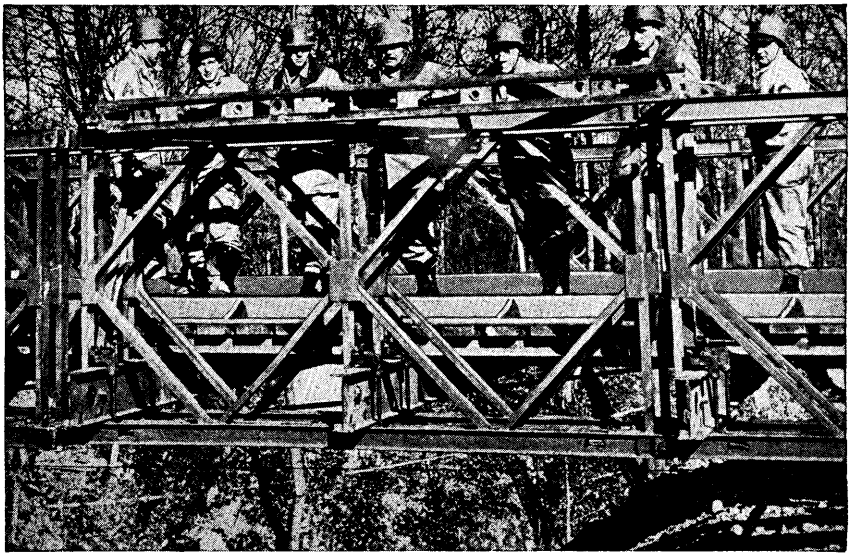


Figure 98. Place panel for third truss on top chord of bridge.

Caution: At end of bridge where transom is in end post, panel and end post must be added as one unit.

h. Position bearings for double-truss construction, jack bridge down on bearings, and replace footwalks (if any).

105. Converting Double-Single to Triple-Single

To convert an existing DS bridge to TS bridge, proceed as follows:

a. Use same procedure as for converting SS bridge to DS bridge for steps *a* to *e* (figs. 98 and 99).

b. Connect outer truss to middle truss with tie plates bolted to top raker holes in the same upright of successive panels (fig. 84). Continue adding panels toward each end of bridge.

c. Jack bridge off bearing (ramps need not be removed) and crib under first and second truss (fig. 100).

Caution: Crib must not extend beyond second truss.

d. Install end panel and end post by raising into position with levers (fig. 101).

Caution: At end of bridge where transom is in end post, panel and end post must be added as one unit.

e. Insert panel pins point inward, slot horizontal. Add tie plates.

f. Shift bearings for double-truss construction to bearings for triple-truss construction (fig. 14). Jack bridge down on bearings (fig. 102). See figure 103 for completed bridge.

g. Replace footwalk (if any).

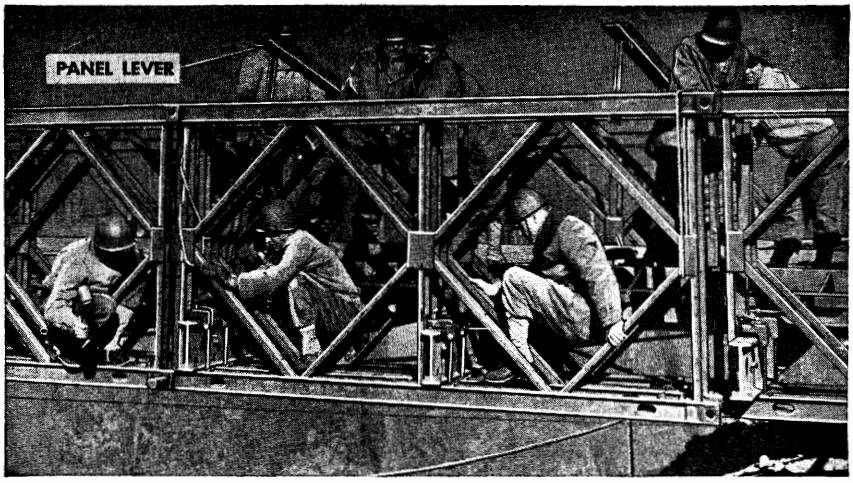


Figure 99. Inserting panel of outer truss. Note use of levers and rope slings to lower panel into position.

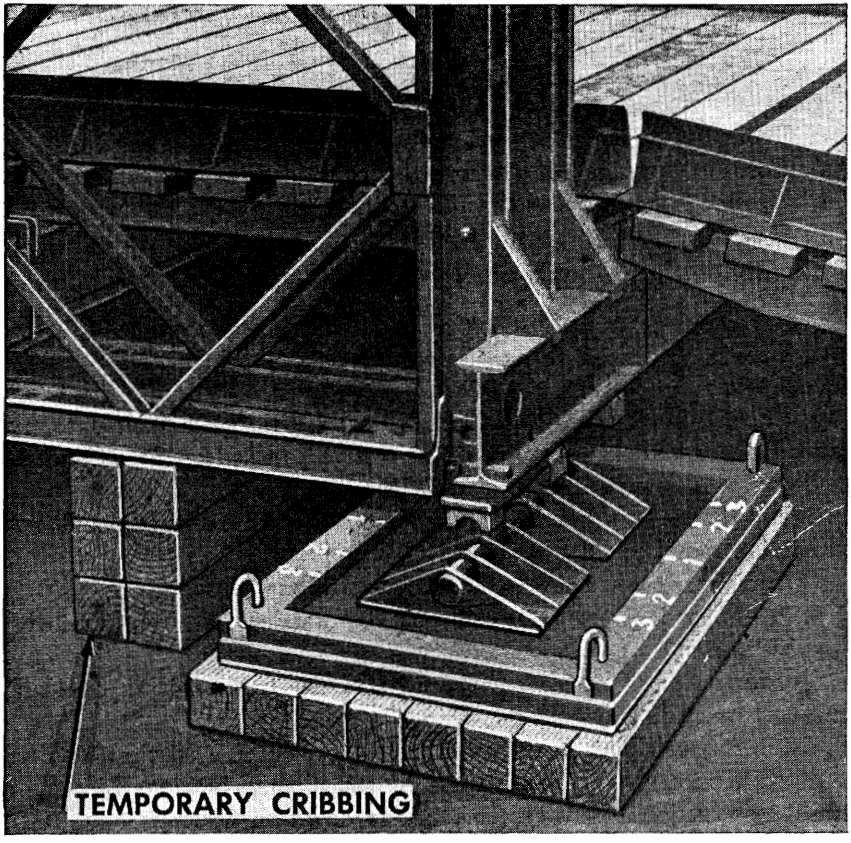


Figure 100. Double-truss bridge jacked-up and cribbed at end where transom is in end post before insertion of outer truss.

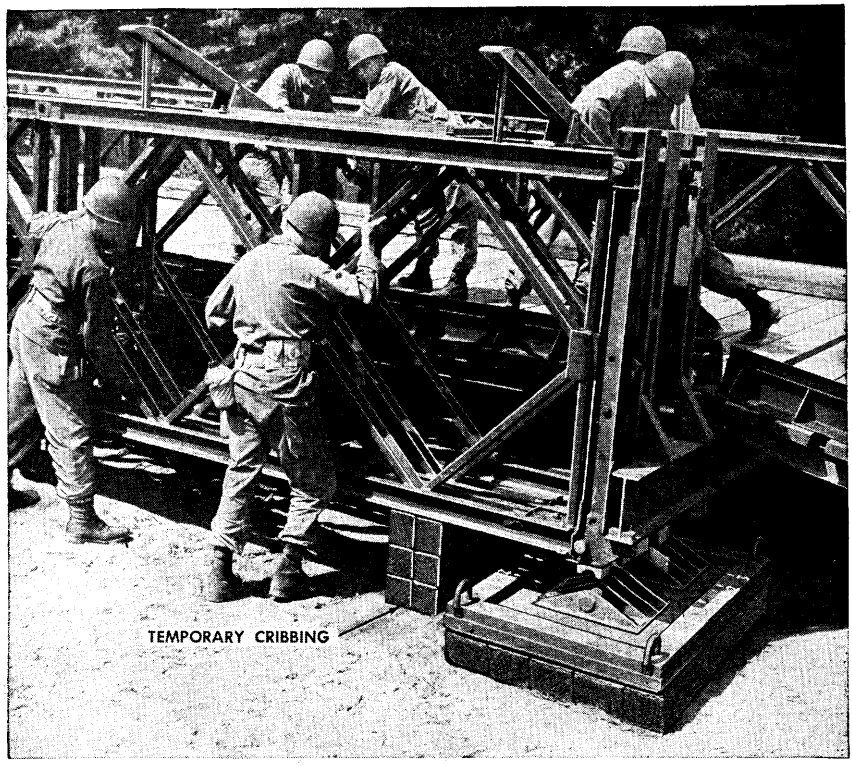


Figure 101. Inserting outer truss. Panel and end post must be installed as one unit at end where transom is in end post. Note use of levers to raise panel into position.

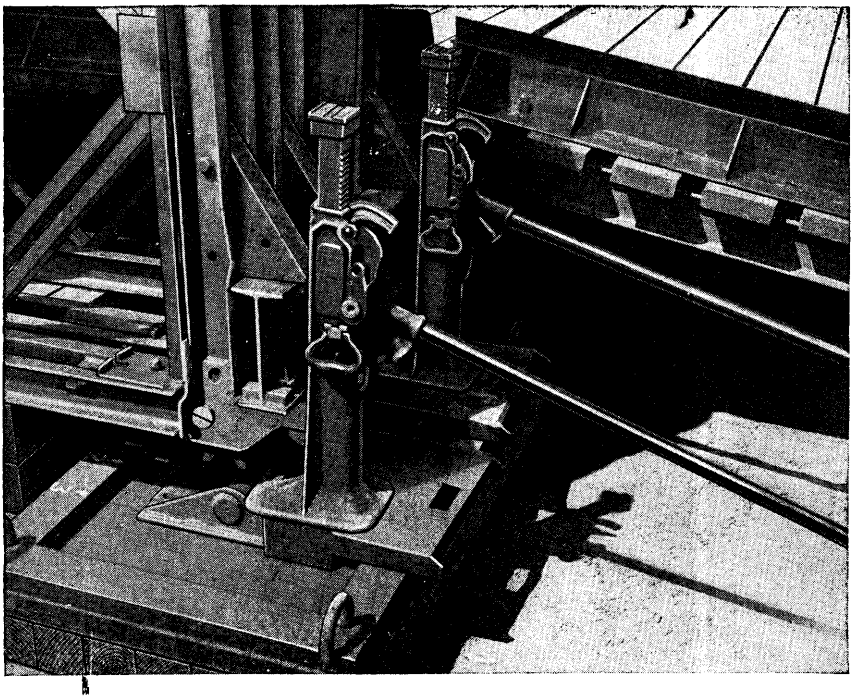


Figure 102. Jacking down after insertion of outer truss and shifting of bearings.

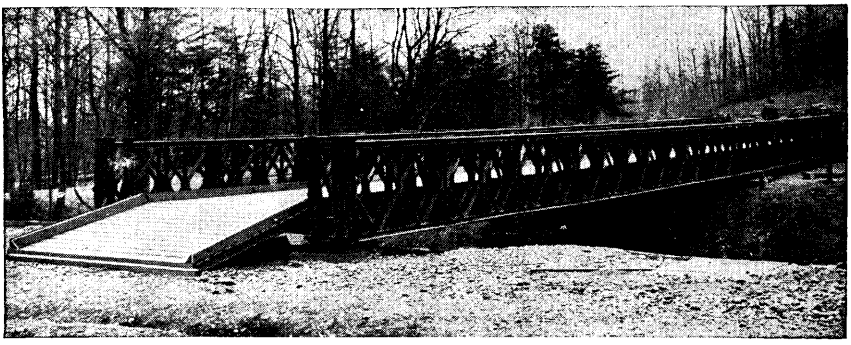


Figure 103. Triple-truss single-story bridge without footwalk.

CHAPTER 12

CONSTRUCTION OF DOUBLE-STORY BRIDGES

Section I. GENERAL

106. Site Lay-out

The lay-out of supplies and the positioning of rollers and grillage are given in chapter 9.

107. Grillage

Chapter 10 gives the types of grillage to be used for various ground pressures. When the span and construction of the bridge have been decided, the type of grillage required must be selected according to the bearing pressure of the ground.

108. Methods of Launching

The same methods of launching are used as for single-story construction. (See par. 85 and part four.) For long heavy bridges, it may be necessary to use bulldozers or trucks. (See par. 122.)

109. Methods of Construction

Methods of construction are similar to those used for single-story bridges. For placing second-story panels, however, the panels can be manhandled from trucks or other platforms. Truck-mounted cranes or gin poles can also be used. With double-story construction it is preferable to assemble the entire bridge before pushing it across the gap.

110. Working Parties

Working parties and construction times for various spans and types of panel bridges are given in chapter 8.

111. Capacity

The capacity of various spans and types of panel bridges is given in chapter 4.

Section II. LAUNCHING NOSE

112. General

The method of assembly of the launching nose for double-story bridges is the same as for single-story.

113. Composition

The number and type of bays used in the nose depend on the span and the type of construction of the bridge. The composition of the launching nose for the various combinations of span and bridge construction is given in tables 39 and 40. *The tables must be followed exactly with respect to the composition of the launching nose.*

Table 39. Construction for Launching Double-double Bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
100	53.0	17
110	59.0	22
120	63.5	24
130	69.0	31
140	76.0	38
150	81.5	41
160	75.5	45
170	81.0	57
180	76.0	68

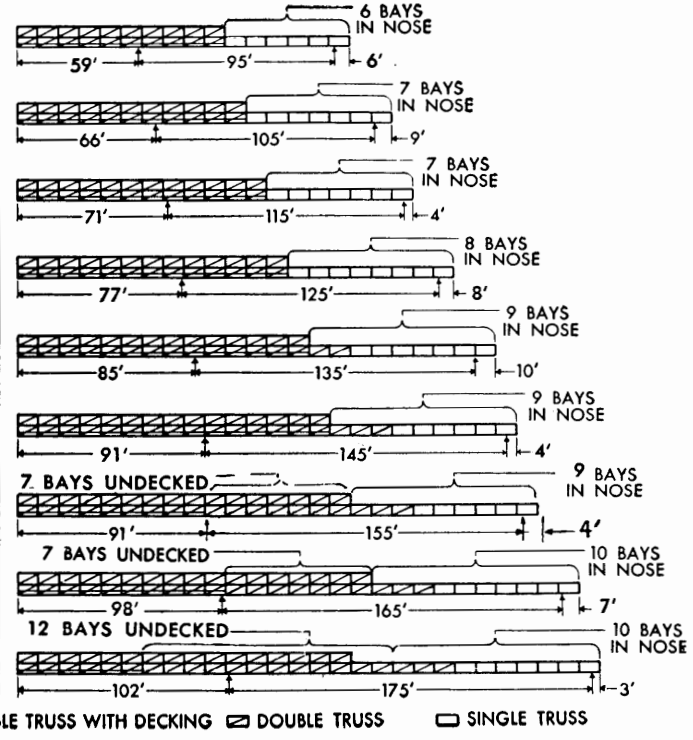
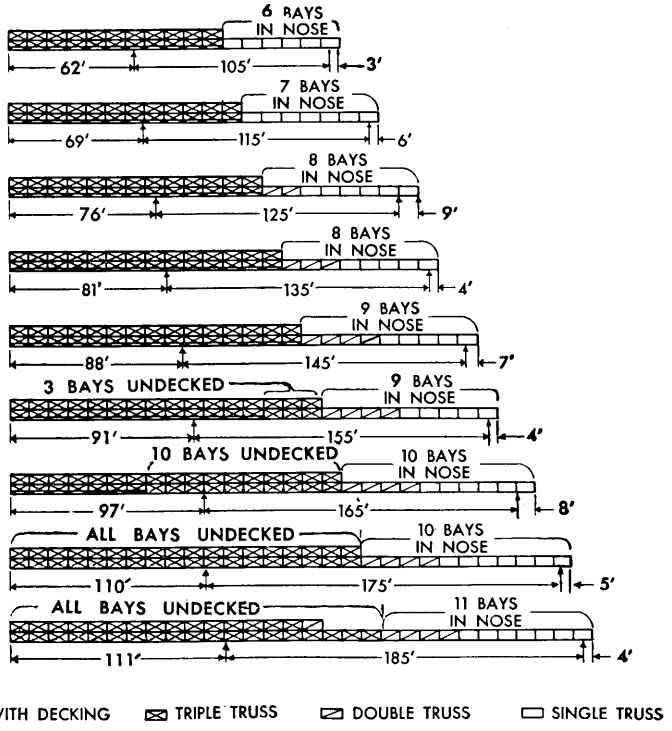


Table 30. Construction for Launching Triple-double Bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
110	71.0	17
120	78.0	22
130	86.0	29
140	93.0	31
150	100.0	39
160	101.5	42
170	98.0	53
180	93.5	60
190	91.5	78



TRIPLE TRUSS WITH DECKING TRIPLE TRUSS DOUBLE TRUSS SINGLE TRUSS

Section III. ASSEMBLY OF DOUBLE-DOUBLE BRIDGE

114. General

The same general assembly methods and precautions used for single-story bridges are used for double-story bridges. Erection of the second story can start either before or during launching or after the gap has been spanned. However, the preferred method is to complete the second story before launching.

115. Nose

See paragraph 92 for assembly of nose.

116. First Bay of Bridge

When construction of nose is completed, assemble first bay of bridge as follows:

a. Assemble three panel bays of DS bridge as shown in figure 104① and described in paragraph 93.

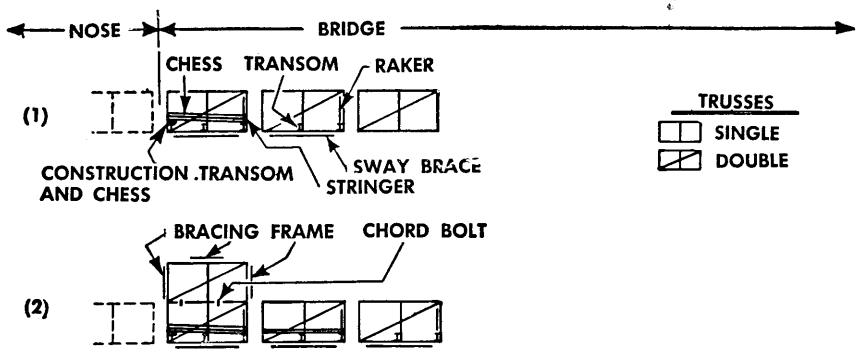


Figure 104. Assembly of first bay of double-double bridge

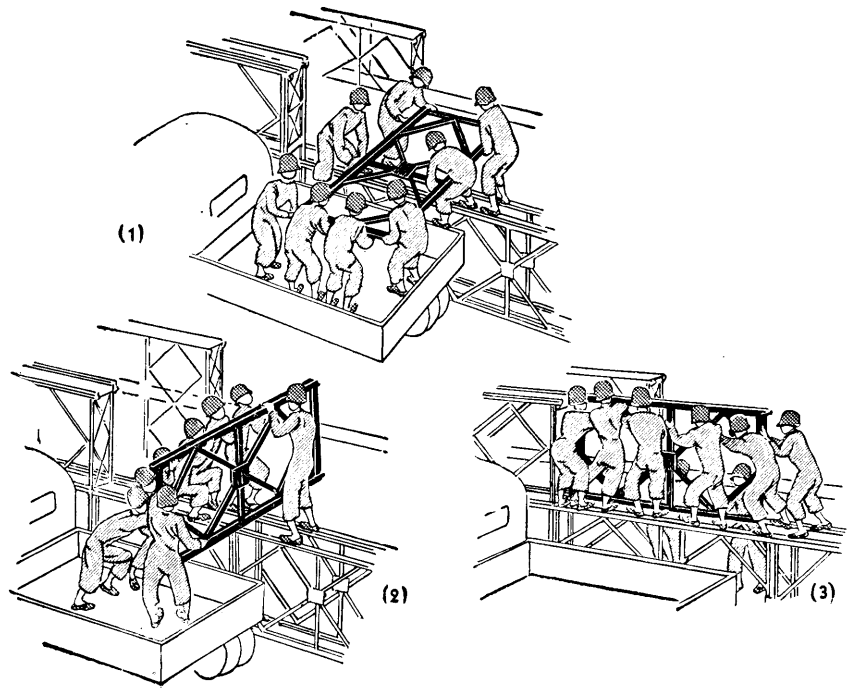


Figure 105. Adding second-story panels, using truck as working platform.

b. Begin double-story construction in first bay of bridge with separate working party (fig. 104②). Continue bottom-story construction at the same time, using the procedure for single-story bridge. The second story always lags by two bays. Use an erection platform when placing

second-story panels. Footwalks can be used as a working platform or panels can be manhandled from trucks maneuvered along the side of the bridge (fig. 105). Panels must be loaded on trucks to allow standing room in the truck for the working parties. The second story is assembled as follows:

(1) Pick up panel from truck at side of bridge, place flat on top chord of bridge. Slide panel in toward center of bridge.

(2) Lift panel upright. Pivot panel so it is parallel to existing truss. Position and pin panel and insert chord bolts, but do not tighten them.

(3) Repeat process with panels on outer truss.

(4) Position bracing frames on front and rear verticals and on top chord.

(5) Tighten chord bolts and bracing frame bolts.

(6) When footwalks are not used and trucks cannot be maneuvered alongside bridge, second-story panels can be placed from a temporary deck inside the bridge or by the use of gin poles.

117. Remainder of Bridge

The remainder of the bridge is built the same as the first bay except bracing frames are positioned on rear verticals and top chord only (fig. 106). When sufficient bays of bridge have been built to counterbalance the nose, move bridge forward so first bay is over the rocking rollers. Movement will not be necessary again during construction unless the overhang at the tail causes excessive sag. When adding panels from outside the bridge, place inner panels first with panel pins inserted from the outside. Then place outer truss panels with pins inserted from the outside. When adding panels from inside the bridge, place the outer panels first and insert all pins from the inside.

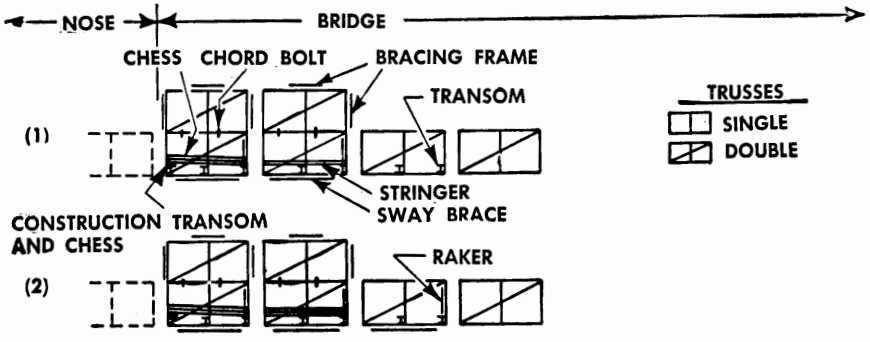


Figure 106. Assembly of remainder of double-double bridge.

Section IV. ASSEMBLY OF TRIPLE-DOUBLE BRIDGE

118. General

Triple-truss double-story assembly is the same as double-truss double-story assembly. With triple-truss construction, however, the outer truss in both lower and second story must lag by one bay to allow insertion of panel pins in the middle truss when panels are added from outside the bridge. When second story panels are added from inside the bridge, the inner and middle trusses must lag by one bay to allow insertion of panel pins in the outer truss.

119. Nose

The method of assembly of the launching nose is the same as for the DD bridge. For the length and construction of nose required for various spans, see table 40.

120. First Bay of Bridge

When construction of nose is completed, assemble first bay of bridge as follows:

a. Assemble four bays of TS bridge as shown in (1), figure 107 and as described in paragraphs 97 and 98.

b. Add double-story construction using the same assembly method as for the DD bridge ((2) and (3), fig. 107).

c. Position bracing frames on the front and rear verticals and on top chord before the chord bolts are tightened.

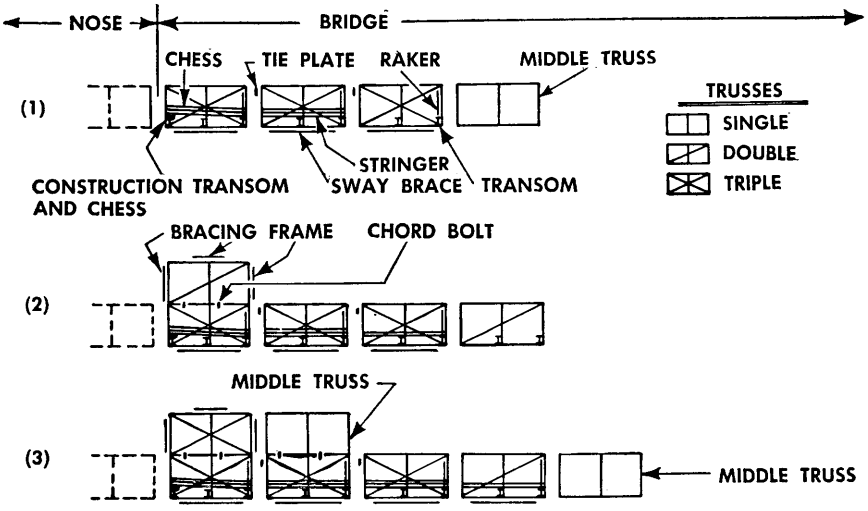


Figure 107. Assembly of first bay of triple-double bridge.

121. Remainder of Bridge

Construct remainder of bridge the same as the first bay except bracing frames are positioned on rear verticals and top chord only. Connect outer truss to middle truss with tie plates bolted to top raker holes in forward uprights of panels in first and second story.

Section V. LAUNCHING AND JACKING DOWN

122. Launching

a. GENERAL. Launching of double-story bridges normally begins after the assembly of the entire bridge. Use the same launching methods and precautions as for launching single-story bridges. When launching with bulldozers or trucks, take the following precautions:

(1) Do not apply power directly to the end of a panel except at the junction of the diagonals. Apply it against the end posts, a transom supported by the end posts, or a transom at the junction of the diagonals. When applying power against a transom, make sure it is distributed across the length of the transom.

(2) Roller heights must be fixed so the tail of the bridge is at least 6 inches off the ground during the entire launching.

(3) Rig a snub line to control movement of the bridge.

(4) If the bridge requires two trucks or bulldozers to move it, use one against end post of each girder.

b. USING BULLDOZER. Two methods that can be used for launching with a bulldozer are as follows:

(1) *With end posts* ((1), fig. 108). Lash transom on its side in end post. Launch bridge with bulldozer blade pushing against transom.

(2) *Without end posts* ((2), fig. 108). Bolt ribands at tail of bridge so that they extend beyond end of bridge. Place transom on its side on the ribands so that the transom rests against the end vertical at junction of diagonals. Face transom lugs toward nose of bridge. Launch bridge with bulldozer blade pushing against transom.

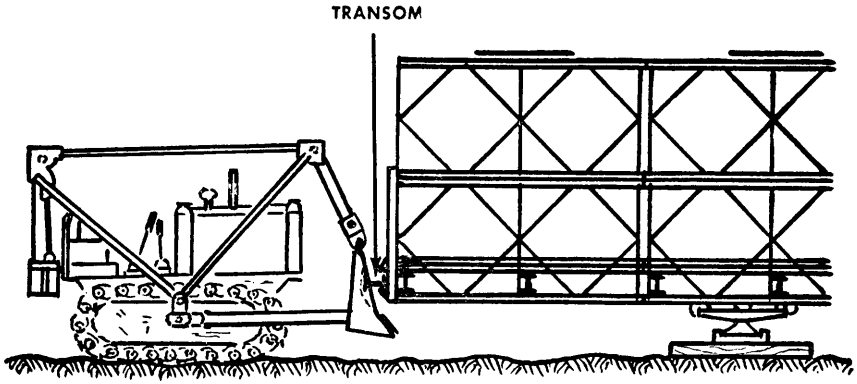
123. Jacking Down

The same jacking methods and precautions are used as for single-story bridges.

Section VI. REINFORCING BRIDGE

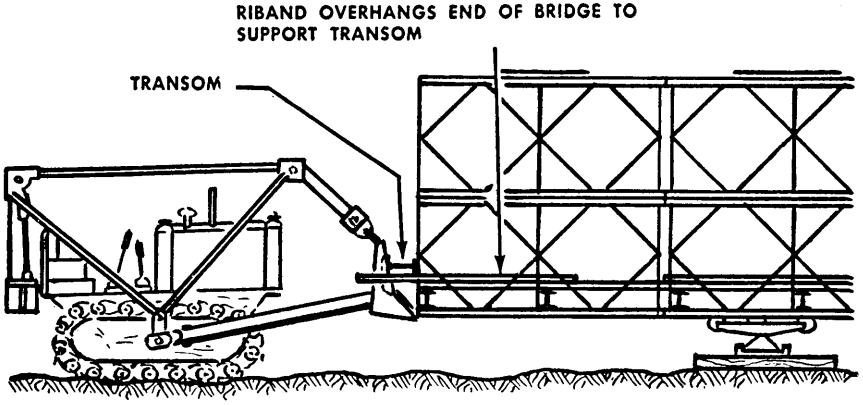
124. General

The load capacity of existing single-story bridges can be increased by adding extra stories.



BULLDOZER PUSHES AGAINST TRANSOM
LAID ON ITS SIDE IN END POSTS

(1)



BULLDOZER PUSHES AGAINST TRANSOM
LAID ON ITS SIDE ON TOP OF RIBANDS

(2)

Figure 108. Using bulldozer to launch bridge.

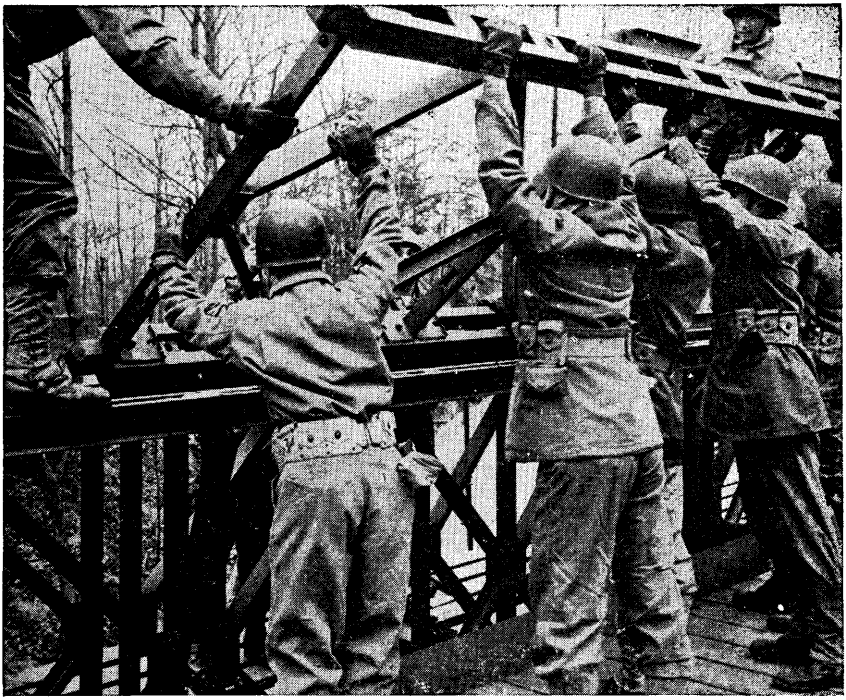


Figure 109. Placing outer-truss second-story panel for converting double-single to double-double bridge.

125. Converting Double-Single to Double-Double

To convert an existing DS bridge to a DD bridge, proceed as follows:

a. Remove bracing frames.

b. Carry first panel to midpoint and place on top chord of existing bridge (fig. 109). Erect outer truss first (fig. 110). Before raising panels, insert wrenches in top chord of existing bridge to prevent panel from skidding out. The inner truss construction should follow closely behind the outer truss in order to obtain erection speed.

c. Insert chord bolts and panel pins. Where necessary, use chord jacks (figs. 111 and 112) to overcome sag when inserting panel pins (fig 113). Tightening chord bolts also helps reduce difficulty caused by sag. *Chord jacks are not required* when adding a second story to double-truss spans 120 feet or less in length, if the following method is used simultaneously on both sides of the bridge:

(1) Place first panel of second story at center of bridge and insert chord bolts. Do not tighten bolts.

(2) Place a panel at each end of the first; insert chord bolts and upper panel pins.



Figure 110. Outer second-story panel in position before insertion of panel pins.

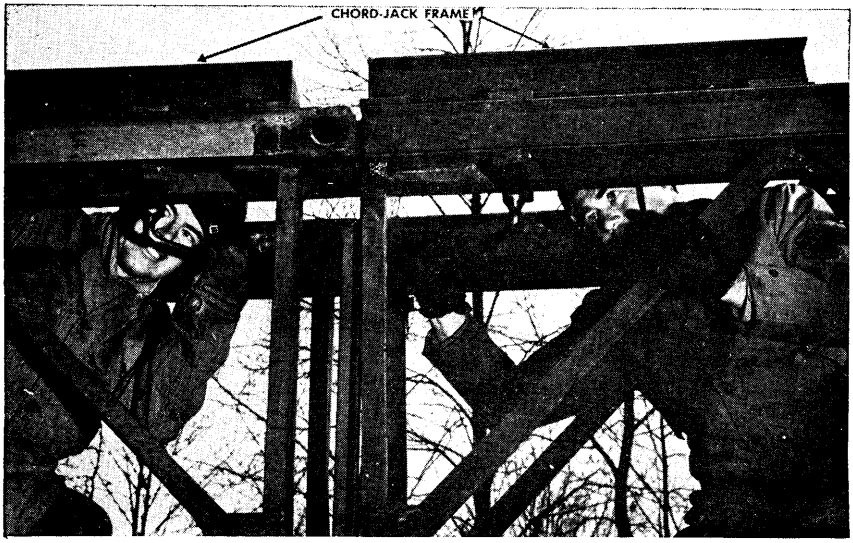


Figure 111. Installing chord-jack frames on top-story inside truss of double-double bridges.



Figure 112. Using chord jack to spread second-story panels of double-double bridge.

(3) Tighten all chord bolts to reduce sag. Drive lower panel pins with sledge.

(4) After the first three panels are in place, add panels one at a time; work toward both ends of the bridge.

(5) As each panel is placed, insert chord bolts. Do not tighten them until upper panel pin has been inserted.

(6) It may be necessary to start and drive upper and lower panel pins simultaneously near the ends of the bridge. Take up on the chord bolts to reduce sag.

d. Place bracing frames vertically on the same end of successive panels and in horizontal position along top chord.

e. See figures 114 and 115 for partially completed and completed bridge.



Figure 113. Driving panel pin in second-story panel using chord jack to spread panels.

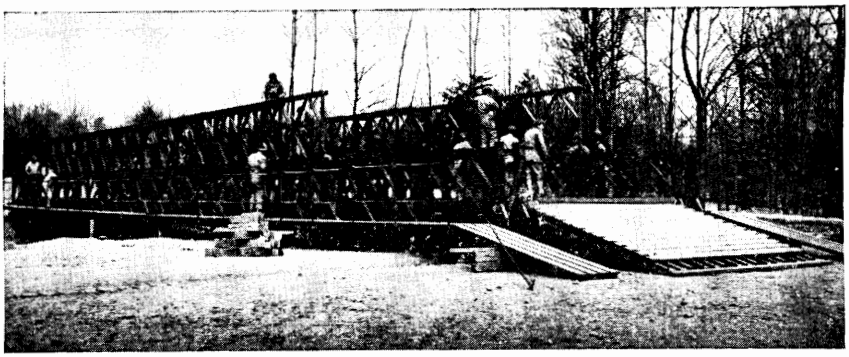


Figure 114. Converting double-single to double-double bridge in position.

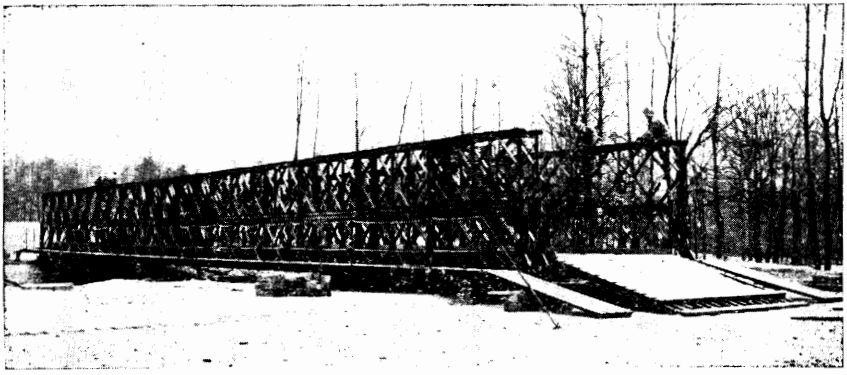


Figure 115. Completed double-double bridge.

CHAPTER 13

CONSTRUCTION OF TRIPLE-STORY BRIDGES

Section I. GENERAL

126. Site Lay-out

The lay-out of supplies and the positioning of rollers and grillage are given in chapter 9.

127. Grillage

Chapter 10 gives the types of grillage to be used for various ground pressures. When the span and construction of the bridge have been decided, the type of grillage required must be selected according to the bearing pressure of the ground.

128. Methods of Launching

The normal cantilever method used for launching single- and double-story bridges is used for launching triple-story bridges. However, some of the triple-story bridges must be launched incomplete to reduce the launching weight.

129. Methods of Construction

Triple-story bridges are normally assembled and launched by mechanical means. However, when truck-mounted cranes are not available, parts can be placed with gin poles or by manhandling. Triple-story bridges can be built with all three stories above the floor system (fig. 116), or with one story underslung below the floor system (fig. 117). When all three stories are above the floor system, the top chord of the upper story must be braced laterally with transoms and sway braces; when one story is below the floor system, lateral bracing in the bottom chord of the underslung story is required only when the force of the wind is more than 50 mph.

130. Working Parties

Working parties and construction times for various spans and types of panel bridges are given in chapter 8.

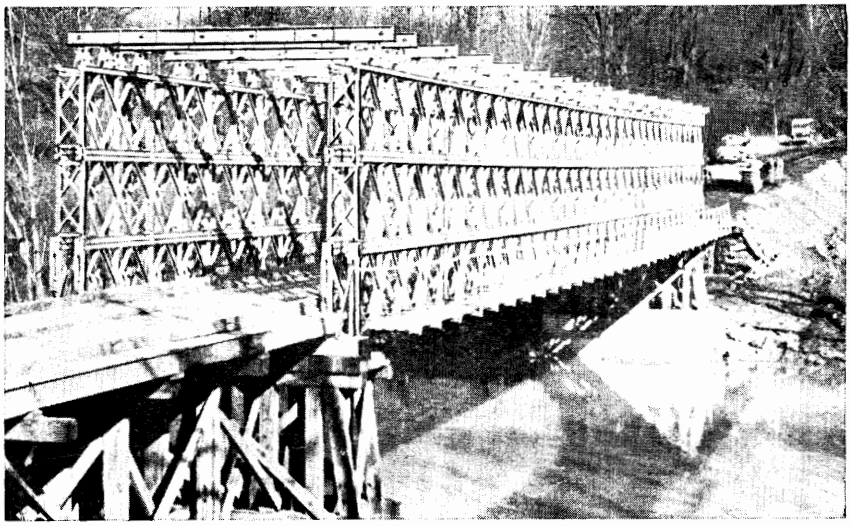


Figure 116. Triple-story bridge with all three stories above the floor system.

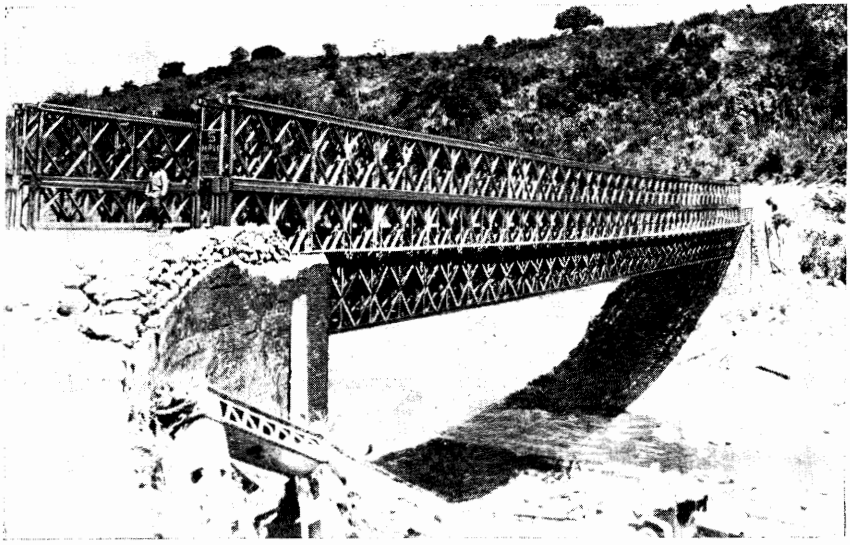


Figure 117. Triple-story bridge with understung story below the floor system.

131. Capacity

The capacity of various types of panel bridges is given in chapter 4. The capacity of triple-story bridges is not affected by the location of the deck or the omission of one story of panels in each end bay.

Section II. LAUNCHING NOSE

132. General

The method of assembly of the launching nose for triple-story bridges is the same as for single- and double-story.

133. Composition

The number and type of bays used in the nose depend on the span and the type of construction of the bridge. The composition of the launching nose for the various combinations of span and bridge construction is given in tables 41 and 42. *The tables must be followed exactly with respect to the composition of the launching nose.*

Table 41. Construction for Launching Double-Triple Bridges

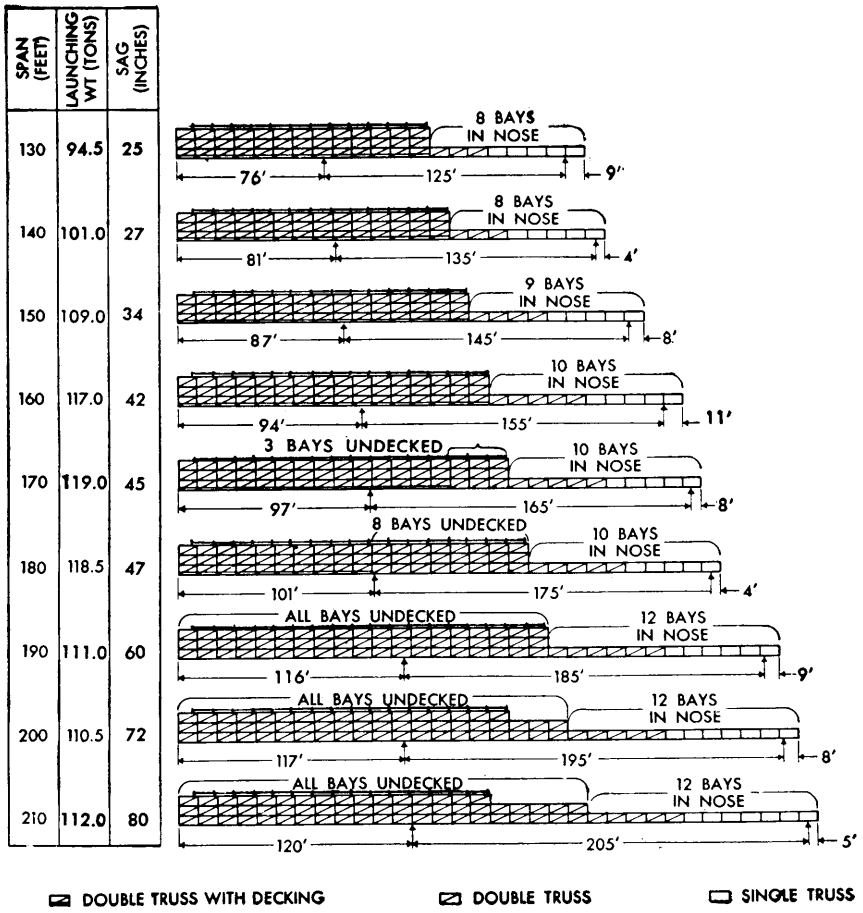
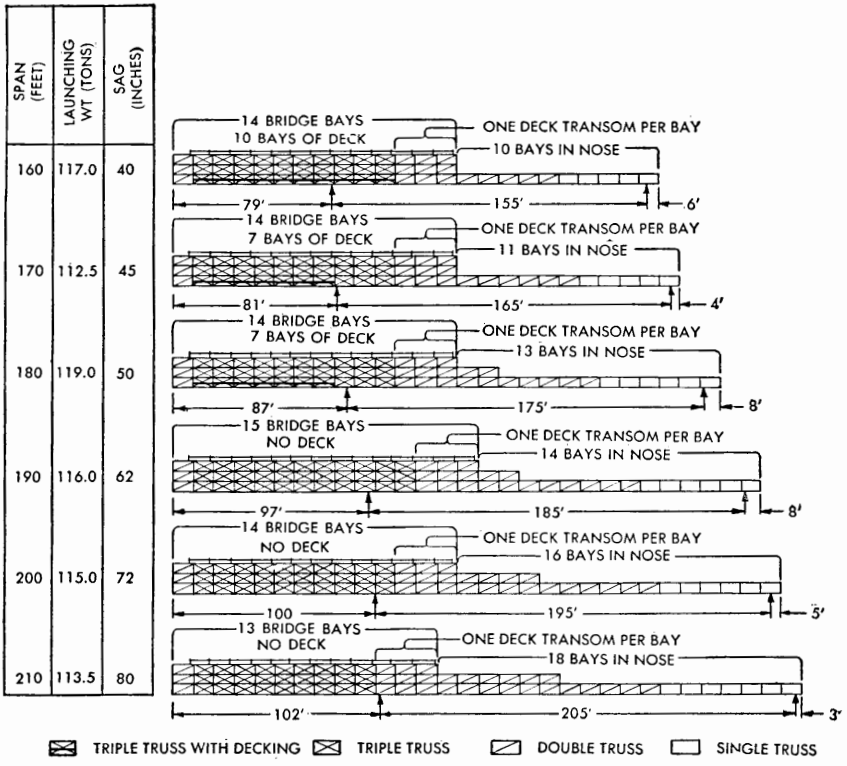


Table 42. Construction for Launching Triple-Triple Bridges



Section III. OVERHEAD BRACING

134. General

The upper story of triple-story bridges, with all three stories above the floor system, is braced by using overhead-bracing supports with transoms and sway braces on the top chord of the upper story or by inverting the third story panels and placing transoms and sway braces in their normal seating in the inverted panels.

135. With Overhead-Bracing Supports

When overhead-bracing supports are used, they are placed one per girder on each bay of the bridge (fig. 118). They are positioned on panels of the inner and second truss over the chord bolt holes nearest the female lugs. This provides clearance for the bracing frames on the top chord. Transoms are fastened to the tops of the supports and sway braces are pinned to the projecting ears on the supports. For a more detailed description of the overhead-bracing support see paragraph 46.

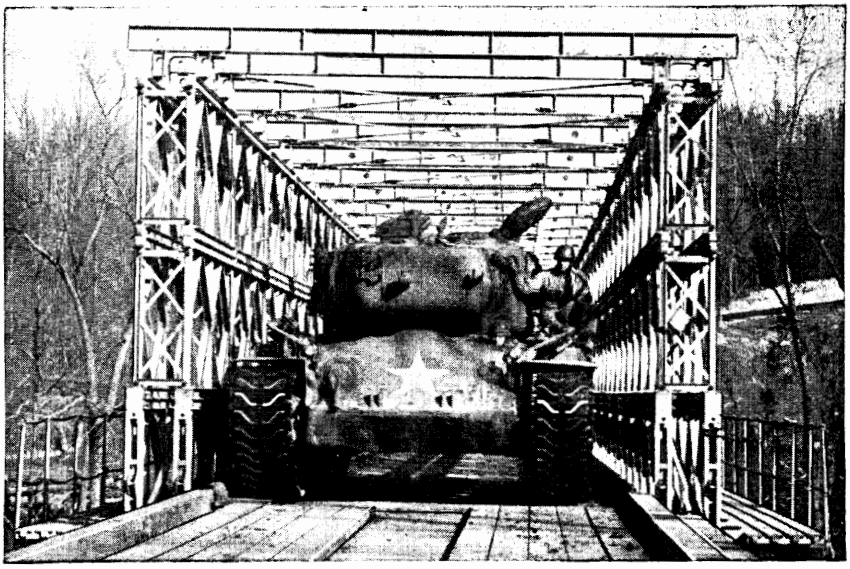


Figure 118. Overhead bracing on triple-story bridge using overhead-bracing supports.

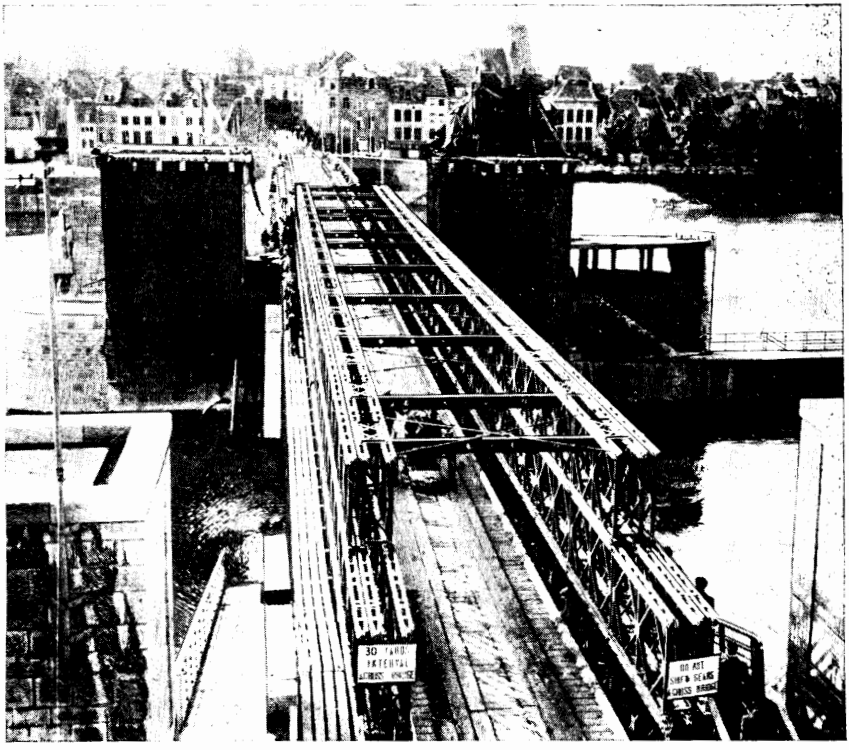


Figure 119. Overhead bracing on triple-story bridge with bracing in inverted third-story panels.

136. Without Overhead-Bracing Supports

When overhead-bracing supports are not used, the panels of the third story must be inverted so that transoms and sway braces can be inserted (fig. 119). Transoms are fitted on the transom seats beneath the upper chord of the top story, and are held in place by transom clamps. Sway-braces are placed in the sway-brace holes in the sides of the upper chord of the third-story panels. One transom and two sway-braces are used per bay.

Section IV. ASSEMBLY OF DOUBLE-TRIPLE BRIDGE

137. General

Double-triple bridges are normally assembled bay by bay on the rollers and launched complete. Some of the longer spans, however, must be launched incomplete to reduce the launching weight. Truck-mounted cranes are used to add the panels in all but the first story of the first bay and to place the overhead-bracing parts. When truck-mounted cranes are not available, parts can be placed using gin poles or by manhandling. Figure 120 shows a DT bridge.

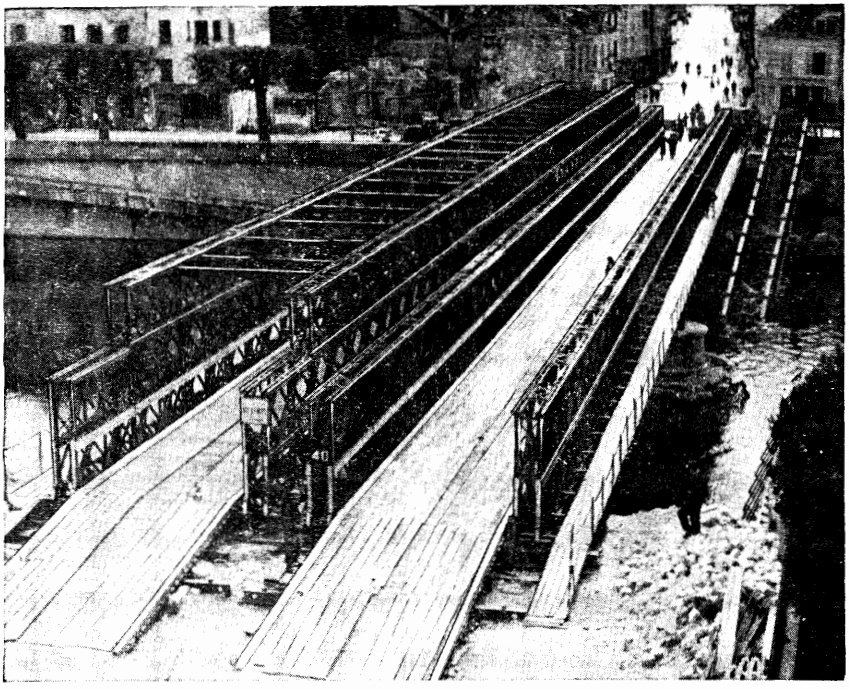


Figure 120. Double-triple bridge at left and double-double bridge at right. Note overhead bracing in inverted third-story panels of double-triple bridge.

138. Launching Nose

See paragraph 92 for assembly of nose.

139. Bridge

a. First Bay of Bridge. When construction of nose is completed, assemble first bay of bridge as follows:

(1) Connect inner and outer truss panels to last bay of nose. Manhandle parts into place.

(2) Add transoms, bracing, and decking in the same way as for single-story bridges.

(3) Add panels to second and third story with cranes. Stock piles are located near cranes to facilitate handling. Bracing frames are placed on front and rear panel verticals in second and third story and on top chord.

(4) Lift overhead-bracing supports with cranes and position over chord bolt holes nearest female lugs of panels. Bolt to girder on one side of bridge only. Bolts on other side are left out because bolt holes may not line up when transom is placed on supports because girders tend to lean slightly toward the center.

(5) Position overhead transom and fasten by the two clamps on each support.

(6) Insert jack between support that is not bolted and outer truss of bridge. Force girders out and insert two chord bolts in the support.

(7) Position overhead sway braces but do not tighten until overhead transom in next bay has been fixed.

b. Remainder of Bridge. The remainder of the panels are placed with the cranes. A single-truss section of two panels is assembled on the ground. When the two-panel section is assembled, a sling is attached, and the section is lifted into place by the crane. Top panel pins are inserted first and bottom ones next. The transoms and deck are added while the rest of the stories are being assembled.

Section V. ASSEMBLY OF TRIPLE-TRIPLE BRIDGE

140. General

Triple-triple construction is not a type of construction commonly used. Because high launching weight may cause failure of rollers or lower chord of bridge, special methods must be used for constructing TT bridges.

141. Methods of Construction

a. Launched as Incomplete Triple-Triple Bridge. To reduce launching weight and prevent overload of rollers TT bridges can be

launched incomplete using the construction given in table 42. The bridge is assembled and launched as follows:

(1) Build nose and partial bridge *exactly* as shown in table 42 according to span and launch to far-bank rollers using normal methods of assembly and launching.

(2) Continue launching bridge over gap until near-bank rocking rollers are under last TT bay of bridge. Dismantle nose beyond far-bank rocking rollers ((2), fig. 121).

(3) Make end DT bay TT and add enough TT bays to obtain required bridge length (six TT bays maximum). This gives the required bridge length for all but the 210-foot span. Because of staggered construction the end bay of the latter bridge must be left DT at this point. Decking in 180-foot and shorter spans can be continued to end of bridge ((3), fig. 121).

(4) Continue launching bridge until near-bank rocking rollers are again under last TT bay of bays added ((4), fig. 121).

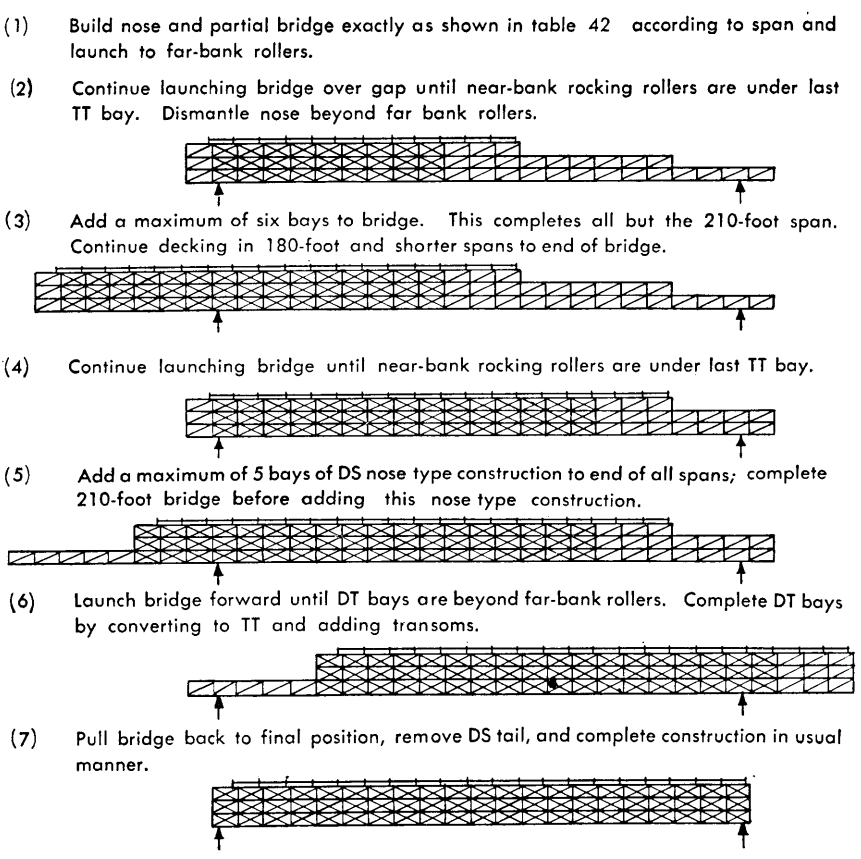


Figure 121. Assembly and launching of incomplete triple-triple bridge.

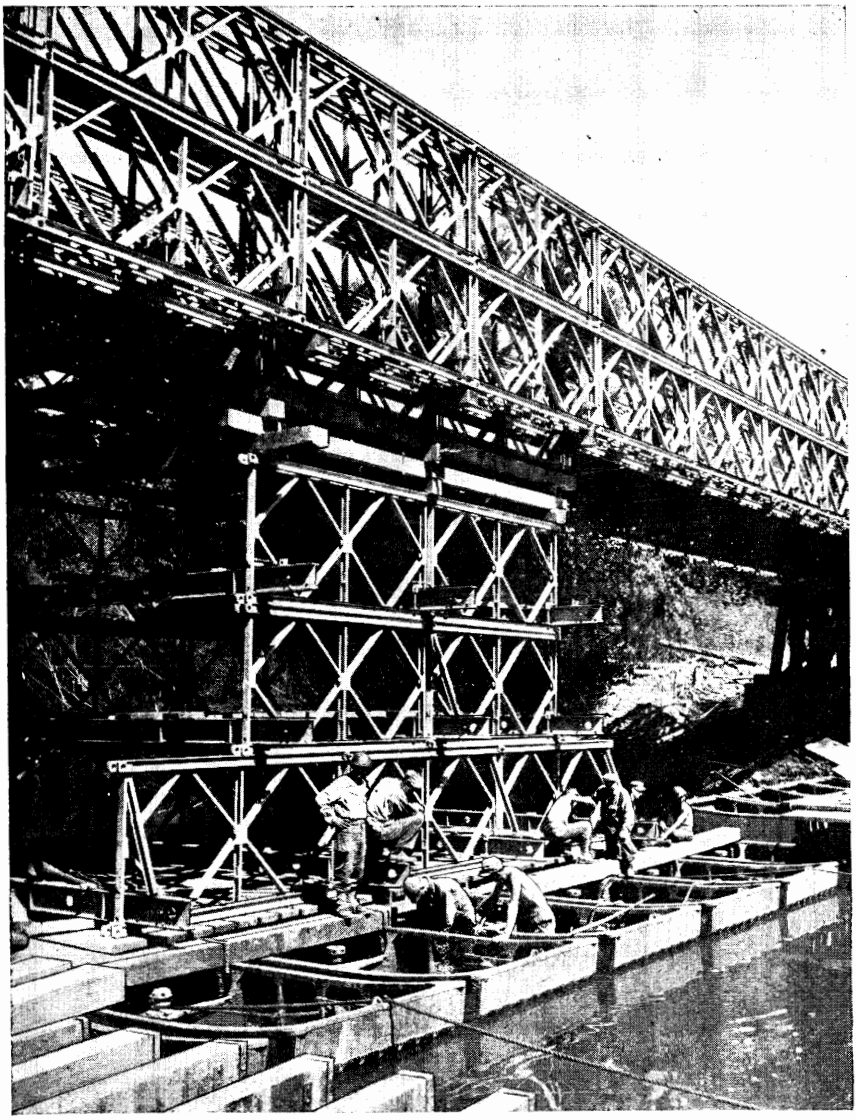


Figure 122. Floating pier used to reduce sag when building triple-triple bridge launched as triple-double.

(5) Add five bays of DS nose type construction to the near-bank end of all bridges ((5), fig. 121). Add enough bays to 210-foot bridge to obtain required bridge length before adding this tail construction.

(6) Launch bridge forward until the three DT bays at front of bridge are beyond far-bank rollers. Complete DT bays by converting to TT and adding transoms ((6), fig. 121).

(7) Pull bridge back to final position, remove DS tail, and complete construction in usual manner ((7), fig. 121).

b. Launched as Triple-Double Bridge Using Temporary Launching Pier. A normal TD bridge is built and launched. At the same time a temporary launching pier is constructed from panel bridge parts. The pier can be offset from the center of the gap so the short span is not less than 60 percent of the long span. After the pier is completed a platform is placed on the top to carry jacks. When the TD bridge has been jacked down onto bearings the jacks are inserted under the bridge at the pier and the bridge jacked up approximately horizontal. A truck crane is then used to place the third story panels and the overhead bracing. Jacking most of the sag out of the bridge makes it possible to place the third story panels. When a fixed pier cannot be used, a floating pier can be used (fig. 122). The pontons are partially filled with water to float the pier under the bridge and then the water is pumped out to raise the bridge. Information on pier reactions is given in chapter 24 and on panel crib piers in chapter 25.

Section VI. LAUNCHING AND JACKING DOWN

142. Launching

It will normally be necessary to launch triple-story bridges by mechanical means. This method of launching is described in paragraph 122. Special care must be taken to see that the construction of the bridge and nose is correct and that the rollers are properly leveled. The launching weight of these bridges is high and slight errors can cause failure.

143. Jacking Down

Normal jacking down methods cannot be used for triple-story bridges. There is not enough room at the end posts to use the required number of jacks. Either jacks of higher capacity or the methods of jacking down bridges on intermediate piers (par. 218) must be used. Using intermediate pier methods requires providing room ahead of the bearings for placing the jacks and the timber grillage under the bottom chord to catch the bridge if the jacks slip or fail.

Section VII. CONSTRUCTION OF BRIDGES WITH UNDERSLUNG STORY

144. General

Triple-story bridges with underslung story are normally assembled and launched by one of the following methods:

a. Launched with underslung story using a temporary launching pier at center of gap. This method is normally used when the launching pier can be positioned.

b. Launched as double-story bridge and underslung story added after bridge is in place. This method is used when launching pier cannot be positioned.

c. Triple-story bridges with underslung story can also be launched as double-story bridge, jacked down approximately 6 feet, and third story added on top chord. This method requires jacking the bridge through an excessive distance and generally is not used.

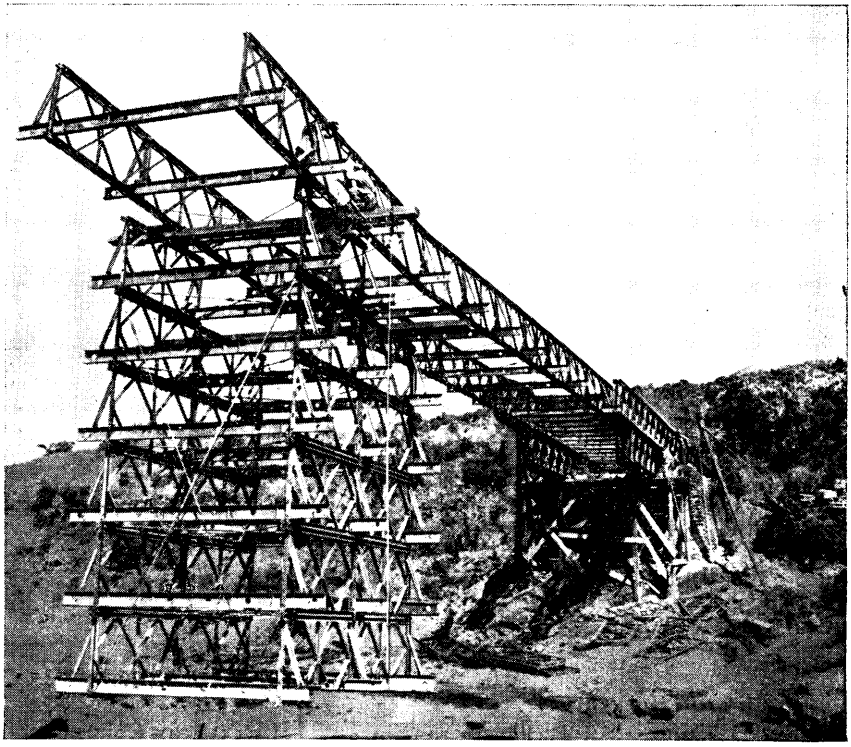


Figure 123. Temporary launching pier used for launching triple-story bridge with underslung story.

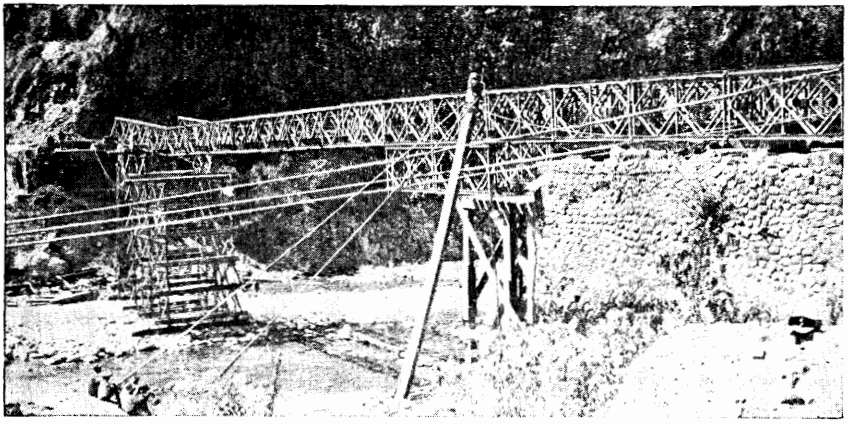


Figure 124. Adding underslung panels to second bay of bridge after launching nose has landed on pier rollers.

145. Using Temporary Launching Pier

This method requires a temporary intermediate launching pier at the center of the gap and sufficient room under the near-bank abutment to add one story of underslung panels. The bridge is assembled and launched as follows:

a. Assemble a panel crib pier at the center of the gap of sufficient strength to carry the completed triple-story bridge (ch. 25). The pier

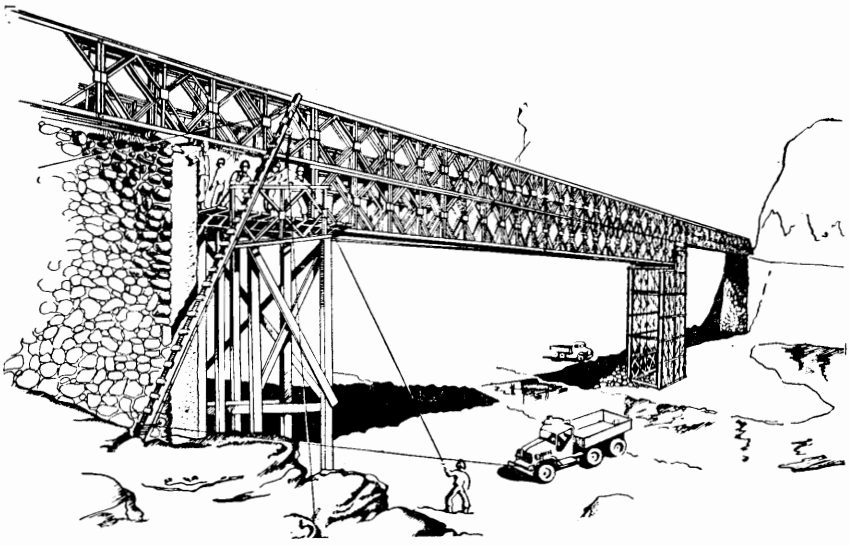


Figure 125. Underslung panels on rocking rollers in first bay of pier. Rocking rollers and one story of panels in second bay of pier is now removed so launching can continue.

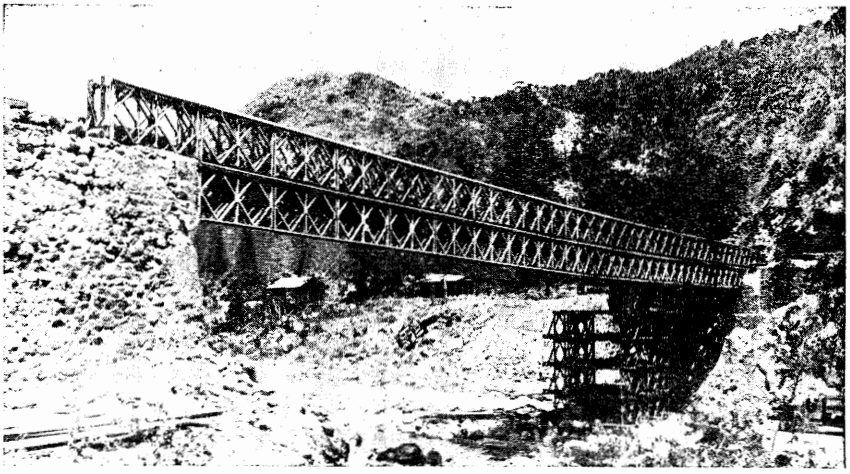


Figure 126. Launching nose removed and bridge jacked down onto bearings.

must have at least two bays of panels horizontal. On the pier bay toward far bank, place rocking rollers at same elevation as near-bank rollers. On pier build bay toward near-bank one panel height below bay toward far bank and place rocking rollers (fig. 123).

b. Assemble double- or triple-truss single-story bridge using normal launching nose and assembly methods for a bridge one half the width of gap (distance from near bank to forward rocking rollers on pier).

c. As soon as nose has landed on pier rocking rollers add underslung panels starting with second bay of bridge (fig. 124).

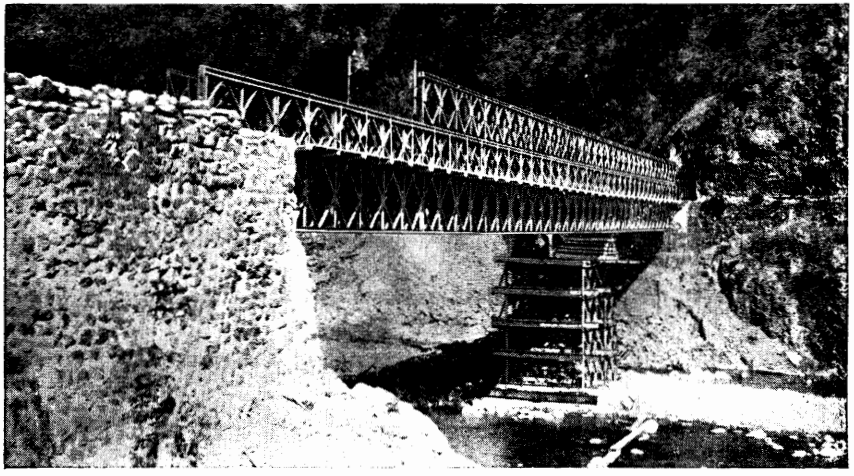


Figure 127. Bridge jacked up at the pier to reduce sag when placing third-story panels.

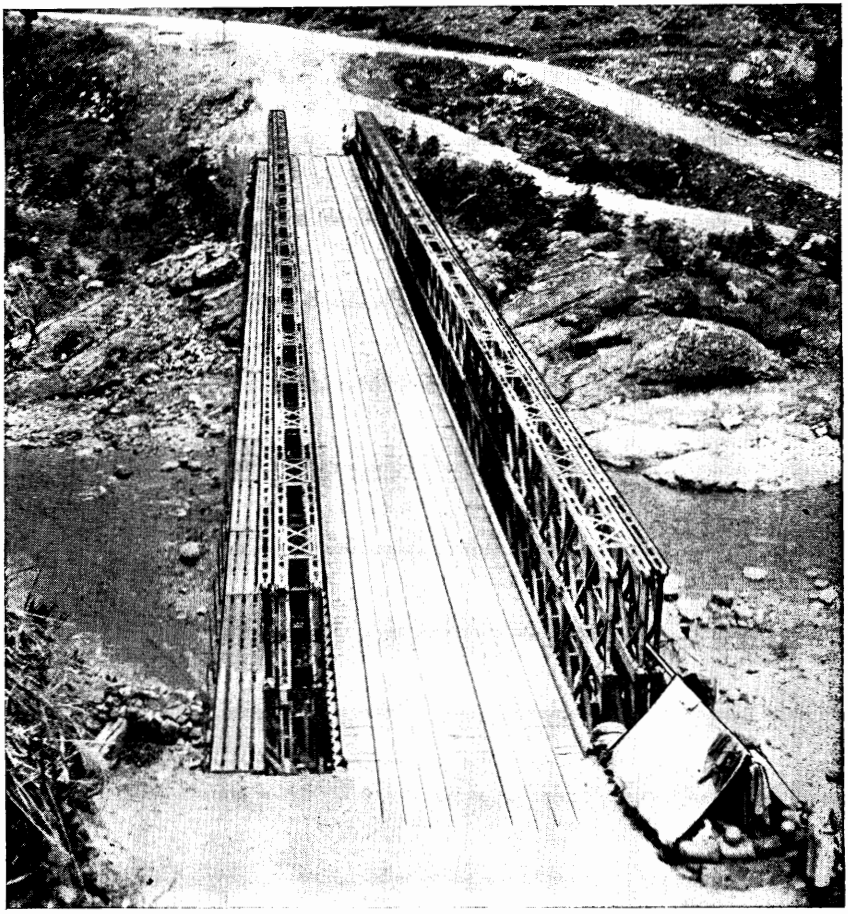


Figure 128. Completed bridge.

d. When underslung panels land on pier rocking rollers (fig. 125), remove pier rocking rollers under launching nose and one bay of panels in pier under launching nose.

e. Continue launching until bridge lands on far-bank rocking rollers. Remove launching nose and position end posts (fig. 126). Before jacking bridge down onto bearings remove one complete story from pier and place a working platform on pier.

f. Jack up center of bridge at intermediate pier until bridge is approximately level (fig. 127). This reduces sag and eliminates difficulty in placing third story panels.

g. Add third story panels, using truck crane, truck, or by manhandling (par. 116).

h. Remove construction pier. Figure 128 shows completed bridge.

146. Construction in Place

An underslung story can be added to a double-story bridge in place by one of the following methods.

a. USING TRUCK CRANE. The easiest and fastest method to add an underslung story to a double-story bridge is by using a truck crane. Single panels are lowered over the side with a truck crane and held in place with chord bolts (fig. 129). Inner panels are placed first. Blocks and tackle are used to position the inner truss panels. Outer truss panels can be positioned directly with the crane.

b. USING BLOCK AND TACKLE AND SINGLE-TRUSS GIRDER. When truck cranes are not available or when the crane causes excessive sag in the bridge, the underslung story can be added as follows:

(1) After the double-story bridge has been assembled and launched, position plain rollers outside of and about 10 inches from the existing outside truss. Place the front roller 3 feet 6 inches from the base plate position and another roller 25 feet from the first. Additional rollers 25 feet apart can be placed if necessary.

(2) Assemble a single truss girder one-half the total length of the bridge minus one bay (not to exceed 12 bays).

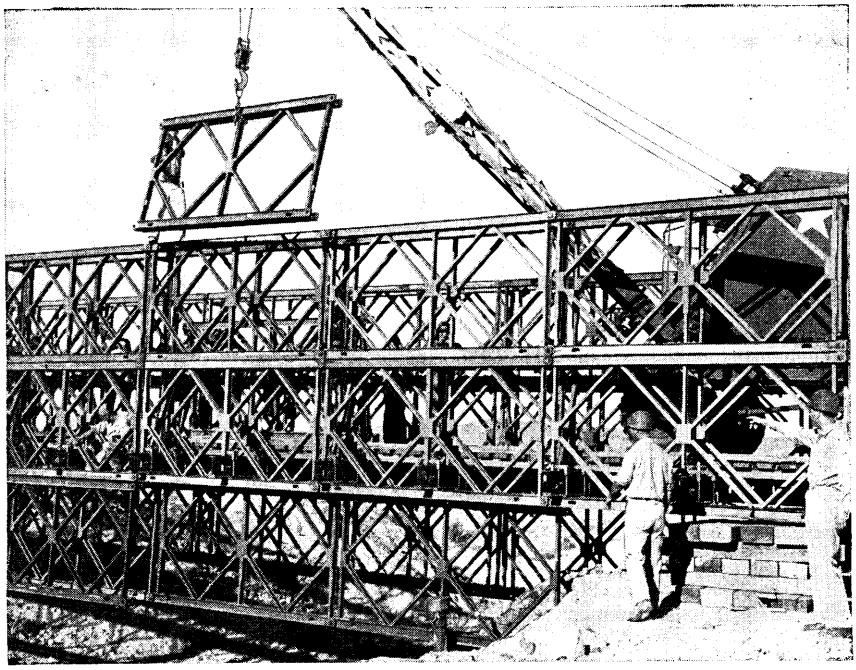


Figure 129. Using truck crane to position underslung panels in triple-triple bridge.

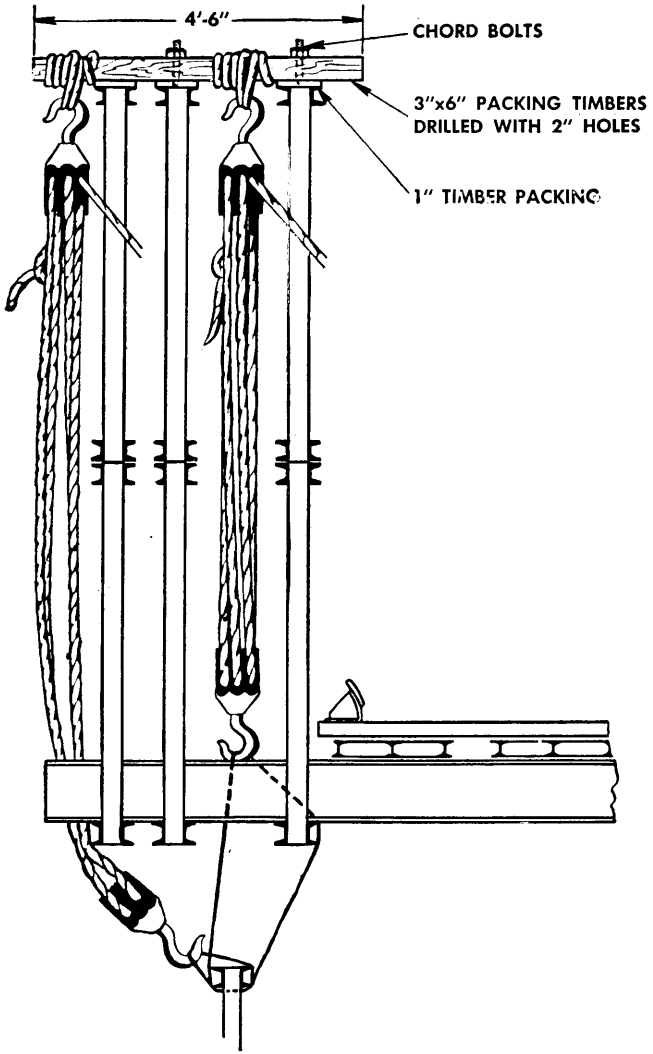


Figure 130. Positioning underslung single-truss girder using block and tackle.

(3) Attach one raker per bay to bottom bracing frame hole on inner truss panel vertical. Lay rakers flat across the bottom chords of the panels so they project beyond the side of the bridge and over the gap.

(4) Place 3-inch by 6-inch packing timbers on top chord of bridge in every fourth bay. Hold in place with chord bolts through chord bolt holes nearest female lugs. Place 1-inch timber packing between grillage and chord. Suspend double- or triple-block tackle from each timber, one at outside end and one between first and second truss.

(5) Launch single girder over plain rollers on bank and rakers on bridge until it is in position to be lowered. Attach outer tackle to girder,

remove rakers, then lower girder until top chord is below bottom chord of bridge. Attach inside tackle and pull girder in toward center of bridge. Inside tackle is attached to the girder with a sling which passes around the bottom chord of the inner truss of the bridge (fig. 130).

(6) Remove outer tackle and lift girder into position under lower chord of bridge with inner tackle.

(7) Insert chord bolts and tighten to fix girder into position.

(8) Remove inner tackle and repeat procedure for the rest of the trusses.

CHAPTER 14

APPROACHES

147. Scope

This chapter briefly discusses the preparation of approaches for panel bridges. For more detailed information on construction of approach roads, see FM 5–10.

148. Requirements

The approach should fulfill the following requirements:

a. Length, Slope, and Width. The approach should be straight for 150 feet at each end of the bridge. Slope usually should not exceed 5 percent (20 to 1). Even though the panel bridge is a single lane bridge, the approach road should be wide enough for two-way traffic to aid in traffic control.

b. Surface. The surface of the approach must be durable enough to stand up under continuous traffic of the heaviest vehicles the bridge will carry.

c. Waiting Area. A vacant lot or field at each end of the bridge is desirable for vehicles waiting to cross the bridge.

149. Construction

a. Use of Existing Roads. If the bridge is built on the site of a demolished bridge, the existing approach roads will normally be satisfactory after the removal of enemy mines and filling in of holes.

b. Construction of New Roads. If the bridge is at a new site, the approach roads are constructed by normal road construction methods.

(1) If the ground is hard and well compacted, drainage may be all that is needed. Add a surface course of gravel or asphalt for heavy traffic. Airplane landing mat can also be used to surface the approaches. The panel bridge set supplies enough light bar-and-rod landing mat for 90 feet of single lane surfacing at each end of the bridge.

(2) If the approach roads are on very bad ground and there is not enough material to provide a relatively hard surface up to the bridge ramp, add an extra timber approach span or plank road, if necessary. Corduroying is also effective, but less desirable.

(3) If the roadway has been excavated or built up, take care to compact the backfill.

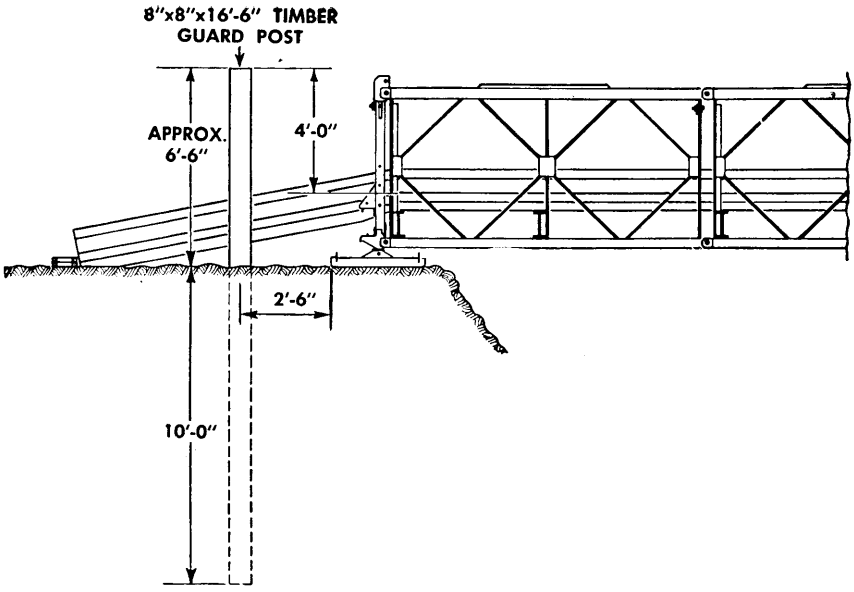


Figure 131. Guard post at end of bridge to protect end posts from damage by vehicles.

c. Height of Road Surface Above Ramp Flooring. To avoid shocks and possible displacement of the bridge from the impact of vehicles striking its end, build up the road surface to about an inch above the flooring of the ramp.

d. Drainage. Proper drainage of the approach road is important. If the drainage is toward the river bank, construct the drainage ditch so it flares away from the bridge abutment to prevent scouring the abutment.

e. Guard Posts. To prevent damage to the end posts of the bridge from vehicles driving onto the bridge, set a heavy guard post in the ground at each end of the inner trusses (fig. 131). Set the posts about 4 feet above the level of the bridge floor and about 2 feet 6 inches away from the base plate. Set the posts into the ground about 10 feet. If this penetration cannot be obtained, brace the post by another post set at an angle back of the guard post. The guard posts can be made from 8- by 8-inch timbers, railroad rails, or steel beams.

150. Maintenance

Heavy traffic tends to develop holes in the road pavement near the end of the ramp causing excessive impact on the bridge. Therefore, arrange for regular inspections and continuous maintenance. Convenient piles of road materials (gravel, asphalt, or landing mat) at each end of the bridge facilitate the repair. Initial reinforcement of this critical section with corduroy or square timbers will often save heavy maintenance later.

CHAPTER 15

TRAFFIC CONTROL

151. Scope

This chapter describes traffic control needed on panel bridges and gives traffic restrictions for safe, caution, and risk crossings of the bridges.

152. Traffic Control

a. TRAFFIC GUIDE. A traffic guide is posted at each end of long bridges or at one end of short bridges. His duties are to—

(1) Enforce traffic restrictions and bar unsafe vehicles. To determine the proper crossings of critical vehicles, he uses a list made up by the bridge officer. The list includes those few vehicles whose weight classes exceed the posted bridge capacity but can cross as safe loads, and those vehicles whose weight classes exceed the posted bridge capacity by more than 25 percent but can cross as caution loads. The guide permits risk crossings only on the order of and in the presence of the bridge officer.

(2) Keep traffic moving to avoid congestion.

(3) When necessary, arrange for alternate flow of traffic and keep bridge exit clear. To avoid congestion, waiting vehicles are parked off the road in a nearby field.

(4) Stop traffic when bridge is damaged.

b. COMMUNICATIONS. The two guides on long bridges have telephones to communicate with each other. Some form of communication is also provided between the guides at the bridge and the guides on the approach roads.

c. APPROACH GUIDES. Approach guides are stationed on the approach roads or at the intersection of the approach road with the main traffic net. They aid the bridge guides by controlling the traffic on the approach roads. Normally, units other than the bridge crew provide the approach guides.

153. Traffic Restrictions

Table 43 lists traffic restrictions for safe, caution, and risk crossings of panel bridges. The 150-inch deck width and the side trusses on the bridge restrict wide vehicles. Figure 132 shows a bridge failure caused by not maintaining proper interval between vehicles.

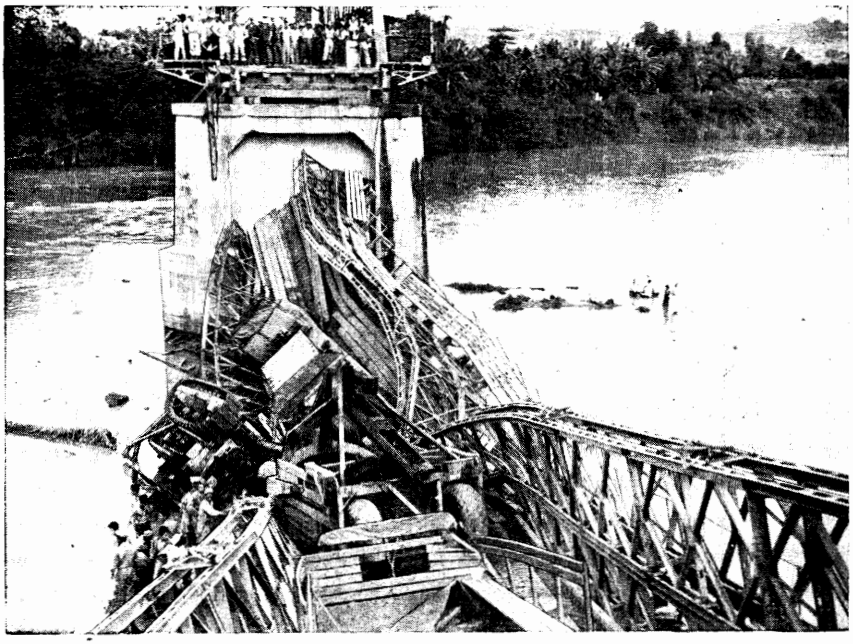


Figure 132. Failure of class 38, 140-foot, DD, M1 panel bridge near Marikina, Luzon, PI. The truck-tractor and 20-ton trailer loaded with a D8 tractor is a class 34 load. Addition of the carryall scraper followed closely by the 2½-ton truck, contrary to 30-yard spacing restrictions for safe crossings, caused failure.

Table 43. Traffic Restrictions on Panel Bridge

Type of restriction	Safe crossing	Caution crossing	Risk crossing
Maximum vehicle weight class.	Equal to posted safe bridge capacity. *or* Bar chart shows vehicle as safe load for bridge.	25 percent greater than posted safe bridge capacity. *or* Bar chart shows vehicle as caution load for bridge.	Bar chart shows vehicle as risk load for bridge.
Maximum vehicle speed.	25 mph	5 mph	3 mph with guide walking in front.
Vehicle position on deck.	Any place	On center line....	On center line.
Minimum vehicle spacing tail to head.	30 yards	50 yards	Only one vehicle on bridge at a time. Normal traffic not resumed until officer has inspected bridge and replaced damaged parts.
Vehicle operation.	No sudden stopping or accelerating.	No stopping, braking, or gear shifting.	No stopping, braking, or gear shifting.

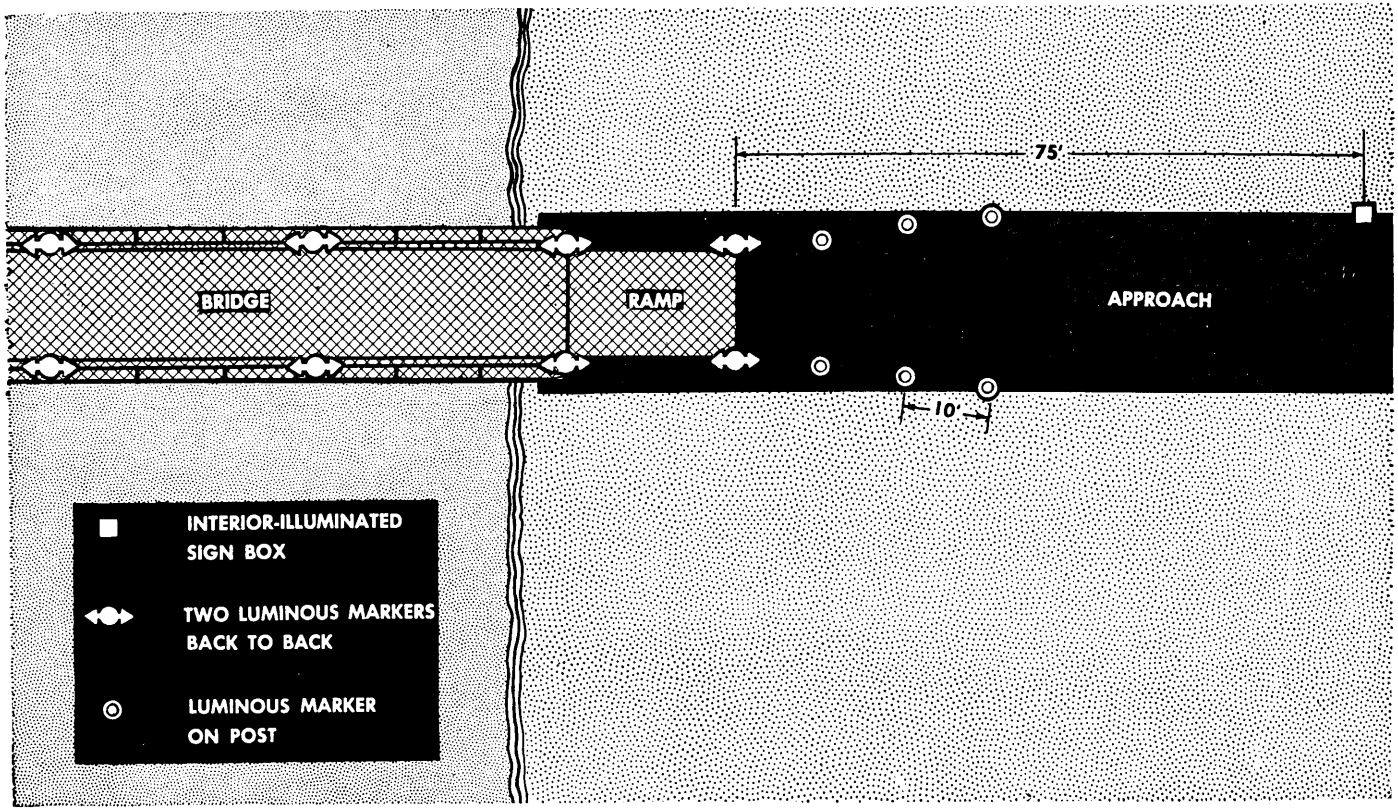


Figure 133. Arrangement of luminous markers on approach and on bridge.

154. Blackout Marking

a. MARKERS. Luminous blackout markers for distinguishing the bridge during a blackout are provided with the bridge set. They are not visible from the air. The markers are visual aids to drivers and help to keep traffic moving steadily. They may be arranged on the bridge and at the approaches in many different ways, according to the type of approach, length of bridge, and light in the sky. Figure 133 shows a suggested arrangement of blackout markers on the approach and bridge. On the bridge, markers are placed on a level with the top of the bottom story.

b. PAINTING. To aid night driving, ribands, end posts, panel chords, and gusset plates on the panels can be painted with white or phosphorescent paint (fig. 134).

155. Posting Bridge

The safe bridge capacity is posted at each end of all bridges. The sign must be at least 17 inches square and is fastened to end posts of bridge. Large numbers on the sign indicate bridge class, and small numbers indicate the bridge span (fig. 135).

156. Pedestrian Traffic

All bridges in town should have footwalks. Bridge guards restrict all pedestrians to the footwalks so they do not interfere with vehicular traffic (fig. 136).

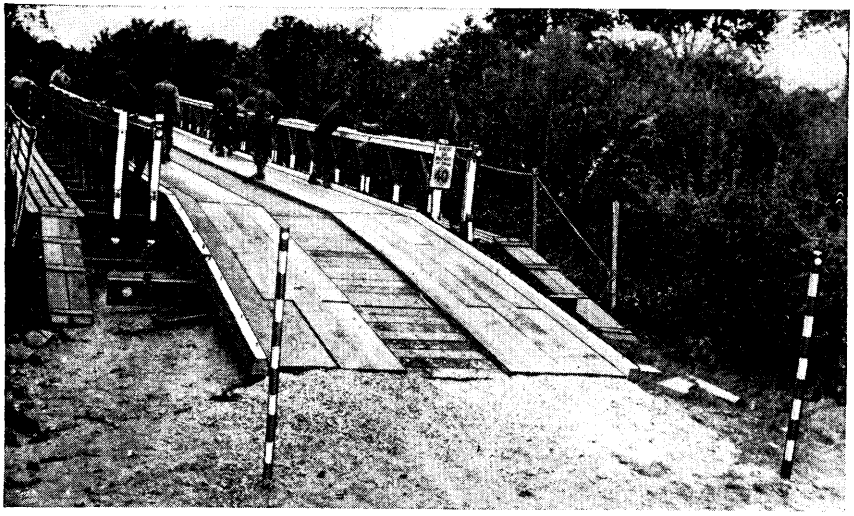


Figure 134. Eighty-foot DS panel bridge at Le Jardin, France. End posts, ribands, panel chords, and gusset plates are painted white to aid night driving. Pickets mark end of ramp. Note luminous button on each picket.

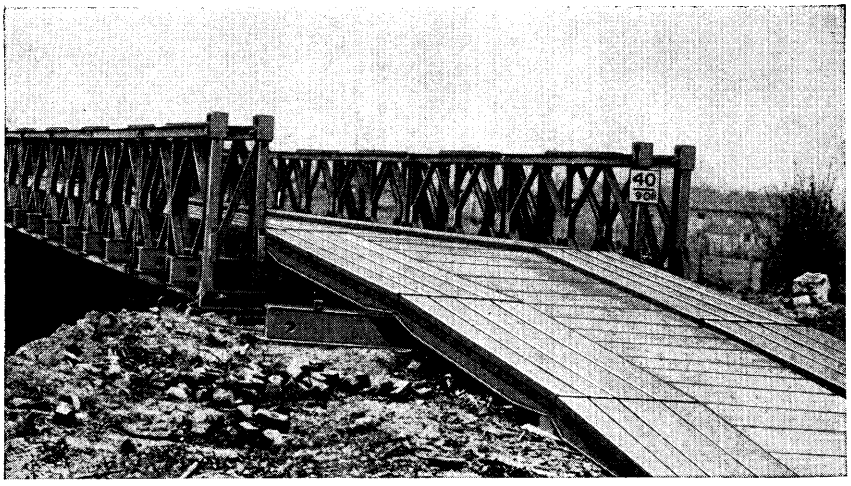


Figure 135. Class 40, 90-foot, DS, M1 panel bridge, somewhere in France. Note sign on end post which indicates bridge class and span.

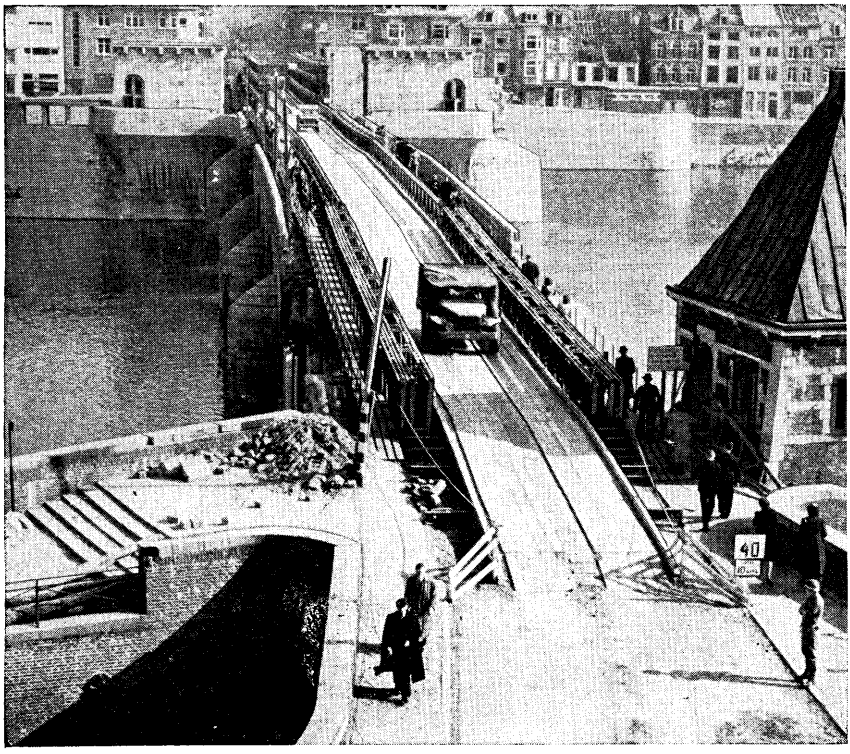


Figure 136. Panel bridge over Meuse River at Maastricht, Holland. Need for footwalks is illustrated by heavy pedestrian traffic.

CHAPTER 16

MAINTENANCE OF BRIDGE

157. Scope

This chapter describes care of panel bridge parts and erection equipment while in storage and while being transported. It also includes maintenance of assembled bridges.

158. Care of Parts and Equipment

a. BRIDGE PARTS. When storing and transporting panel bridge parts, keep them clean and lubricate as follows:

(1) Panels: Grease jaws and inside of all holes. Panels are easily distorted by improper storage and handling. Whenever possible, store them in an upright position. If it is necessary to store them horizontally for stability, do not stack more than 10 on a flat base.

(2) Bracing frames, rakers and tie plates: Grease conical dowels.

(3) End posts: Grease curved bearing surfaces and pinholes.

(4) Bearings: Grease bar segments.

(5) Panel pins: Grease shanks.

(6) Sway braces: Grease threads and pins.

(7) Bolts: Grease entire bolt.

b. ERECTION EQUIPMENT. Protect pieces of erection equipment, such as rollers, jacks, panel levers, pin extractors, and wrenches, by keeping them clean and lubricated to prevent rust.

c. ROLLER LUBRICATION. Before launching a bridge, lubricate bearings of plain and rocking rollers through grease fittings at both ends of shafts. To lubricate plain rollers completely—

(1) Clean out old grease and dirt around shaft at each end of both rollers.

(2) Wedge rollers tight against outer bearings where grease fittings are located.

(3) Add grease until it is forced out around shaft at inner bearings.

(4) If no grease appears at inner bearing of either roller, disassemble and clean entire unit.

(5) After reassembling the roller, repeat steps 2 and 3.

159. Maintenance of Bridges

a. MAINTENANCE DETAIL. (1) *Size.* For important bridges subject to enemy action the maintenance party usually consists of the entire

erection crew. For routine repair work, however, the detail consists of only six men. In rear areas, one traveling crew maintains all bridges in an assigned area or route.

(2) DUTIES. The maintenance detail—

(*a*) Checks bridge thoroughly after first 30 minutes of use and periodically thereafter for tightness of bracing bolts, chord bolts, transom clamps, and sway braces.

(*b*) Examines base plates and grillages periodically for uneven settlement and adds grillage when necessary.

(*c*) Checks tightness of packing under end transoms and ramps.

(*d*) Makes sure all panel safety pins are in place.

(*e*) Lubricates all exposed threads and occasionally pours a small quantity of oil over each panel joint if the bridge is to remain in place for a long period or if it is to be dismantled in freezing weather.

(*f*) Repairs wearing surface on deck and ramps, and keeps stone and gravel off deck.

(*g*) Maintains immediate approaches and drainage ditches.

(*h*) During heavy rain storms, checks closely for erosion of bank seats, abutments, approaches, and drainage ditches.

(*i*) Replaces damaged end-post guards.

b. TOOLS. Tools for routine maintenance work are listed below:

Wrench, ratchet (for double- and triple-story bridges only)	1
Wrench, socket, 1⅛-inch	2
Wrench, structural, 1⅛-inch	2
Wrench, structural, 1⅞-inch	1
Wrecking bar	1
Clawhammer	1
Carpenter's level	1
Hand crosscut saw	1
Sledge, 6-pound	1
Shovel, long-handled	1

For bridges subject to enemy action, complete erection equipment must be kept available at the site.

c. SPARE PARTS. Bridge trains (table 27) include approximately 10 to 25 percent spares for all bridge and nose parts except bearings, ramp pedestals, pickets, base plates, ramps, and ribands. For replacing damaged parts of bridges subject to enemy fire, the spare parts in the bridge train and additional parts covering the above exceptions are dispersed about the bridge site after completion of the bridge. Depending on the tactical situation, the spares may be increased up to 50 percent for forward area bridges. Rear area bridges require only enough spare deck parts and wear tread planking to replace those worn or damaged by normal use.

CHAPTER 17

REPAIR OF DAMAGED BRIDGES

160. Scope

Damaged deck and bracing parts can be easily replaced with spares. Replacing damaged panels is practically impossible, however, without first delaunching the bridge, which is difficult and time-consuming. If panel damage results in greater loss of capacity than can be tolerated, the bridge can be repaired by reinforcement (ch. 23) or welding. Reinforcement is preferred because welding can cause serious additional damage unless it is done under favorable conditions by experienced personnel. This chapter gives the correct application of both methods.

161. Assessment of Damage

Choice of method depends chiefly on nature and extent of damage and also on available repair equipment. First step in all repair jobs is therefore assessment of damage (app. I) to determine effect on bridge capacity and type and location of necessary repairs.

162. Reinforcement

a. WEB DAMAGE. Shear capacity lost by damage to panel vertical and diagonal members is restored by adding complete trusses or partial stories or replacing damaged bays.

(1) Repair damaged SS bridges by adding complete trusses.

(2) Use complete truss when damage extends through several bays of double-truss bridges.

(3) Add partial story when damage is confined to one or two bays of long spans. Partial story must extend two bays beyond both ends of damaged panels. In case of damage to first or second end bays partial story extends from end of bridge to two bays beyond damaged panels.

(4) If the end bay of double- or triple-story bridges is seriously damaged it must be replaced. Jack bridge onto launching rollers and build new bay at undamaged end of bridge. Roll new bay over gap, dismantle damaged bay and lower bridge onto original bearings.

b. CHORD DAMAGE. If chord and web damage occur together, repairs are made according to the above rules. Damage to exterior chords alone can be repaired with supplementary chords extending two bays on both sides of the damaged panel. Modified bracing frames must be used with

supplementary-chord splices of the top chords of double- and triple-truss bridges to maintain a continuous bracing system (fig. 194).

c. CAPACITY. (1) *Partial stories and supplementary chords.* The posted capacity of the bridge must be reduced by the dead weight of the partial story or chord splice.

(2) *Complete truss.* The capacity of a girder reinforced with a complete truss is determined by the method for assessment of damage in terms of reduction of load class (app. I).

163. Welding

a. GENERAL. All panel-bridge parts can be repaired by welding. Damaged parts which can be removed, however, are preferably replaced with spares. Repair work must be carefully done to prevent distortion and insure proper fit of all parts.

b. DESIGN. Splice plates secured by fillet welds are more reliable than butt welding alone. Splice material should be mild-steel plate about 50 percent greater in cross-sectional area than damaged section of the member being repaired. Splice plates should be arranged to match as closely as possible the shape and position of the damaged section they replace. Minimum length in inches of ¼-inch fillet weld required on each end of a splice plate is 10 times the cross-sectional area of the plate in square inches (fig. 137).

¼" weld: L (inches) = 10 × A (square inches)

If ⅜-inch fillet welds are used, the factor is 7 instead of 10.

⅜" weld: L (inches) = 7 × A (square inches)

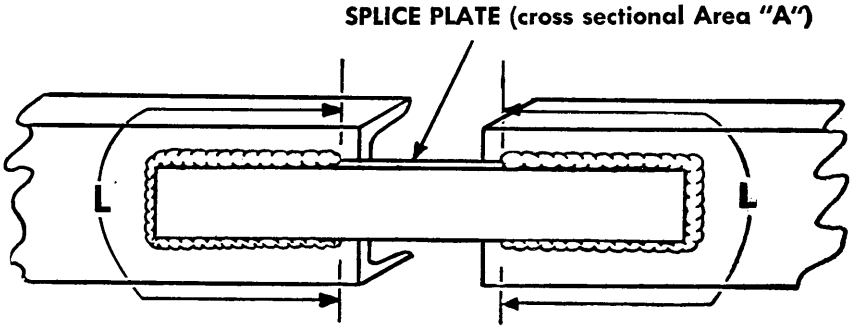


Figure 137. Effective length of weld on each end of splice plate.

c. PROCEDURE. (1) *Preliminary work.* Before making welded repairs, it is necessary to clear the area around the fracture by cutting all jagged edges. Straightening is always done cold.

(2) *Welding technique.* Both mild-and high-tensile low-alloy steels of American parts can be repaired by either electric-arc or oxyacetylene weld-

ing (TM 9–2852). For electric-arc welding, the heavily coated mild-steel shielded-arc electrode (Lincoln Fleetweld No. 5 or equal) included in the electric arc-welding set No. 1, is the most satisfactory. If welding is done by the oxyacetylene process, a copper coated mild-steel rod should be used.

d. Panel Repair. Cases of typical chord damage with correct repair methods are shown in figure 138. Figure 139 shows typical damage and repair of panel web members. It is possible to use a standard set of strips in many cases, the more useful sizes being 3½ by ¼ by 12 inches, 2½ by ¼ by 12 inches, and 1¼ by ¼ by 12 inches. The choice of strip sizes is determined by the requirement of using downhand welding wherever possible.

e. Repair of Removable Parts. Removable parts can be repaired under the same general procedure for panel members. Splice plates on transoms must not interfere with stringers or positioning the transom seats on the girders. Welding of the lighter parts must be done carefully to prevent distortion and loss of interchangeability.

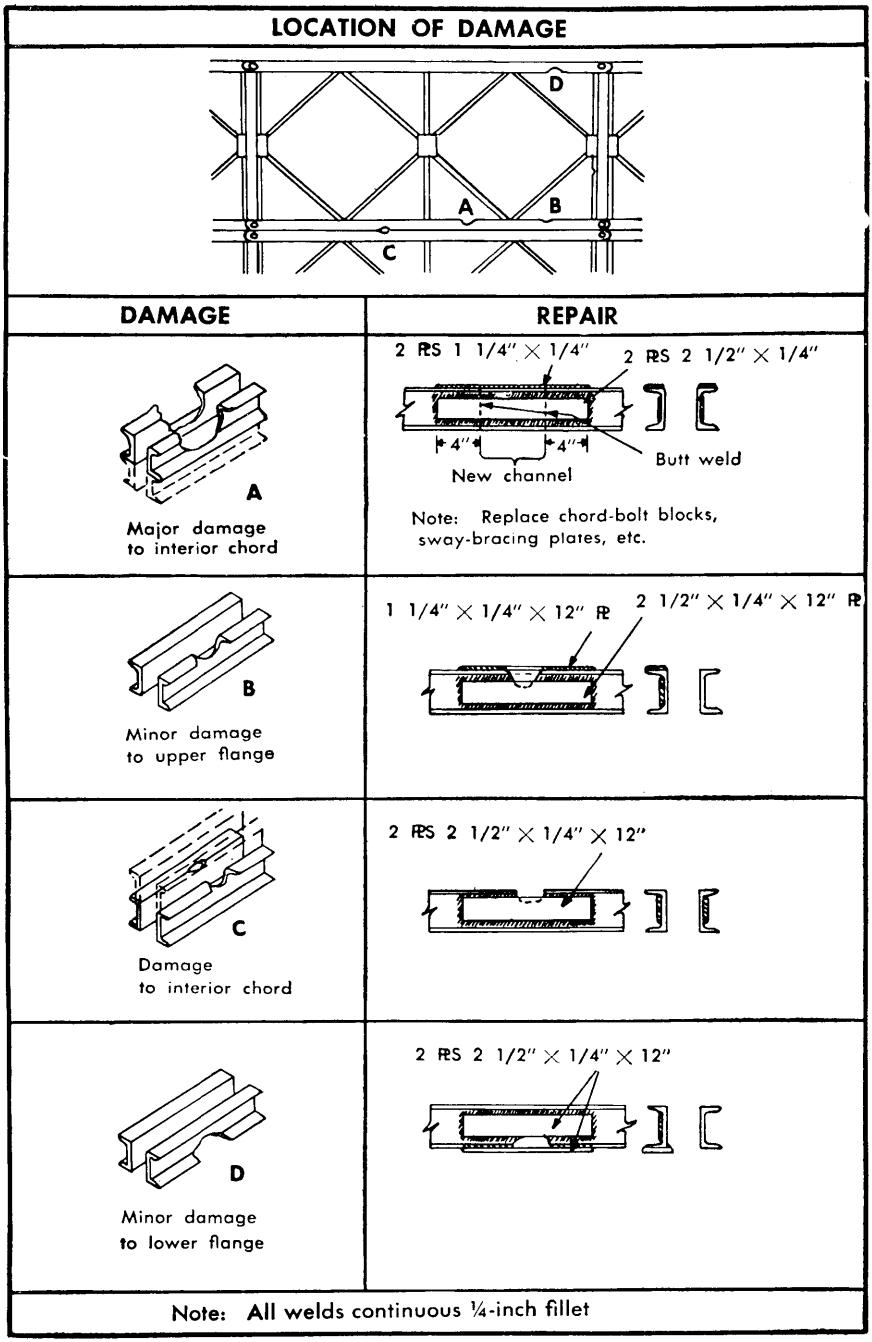


Figure 138. Typical panel chord welding repairs.

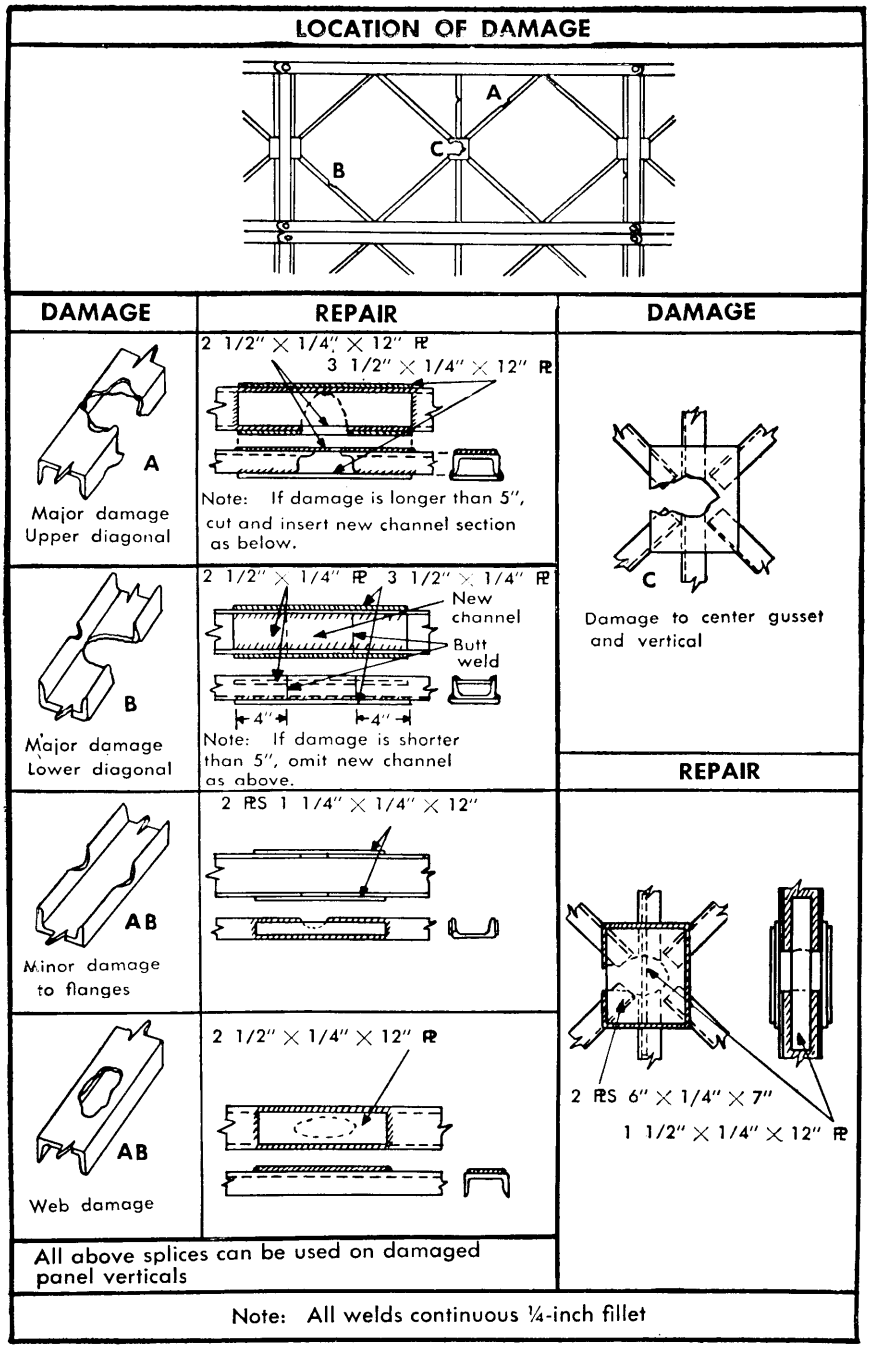


Figure 139. Typical panel web member welding repairs.

CHAPTER 18

DISMANTLING AND REPLACING BRIDGE

164. Dismantling Bridge

a. GENERAL. Panel bridges are temporary structures and must be replaced as soon as practicable with semipermanent bridges. A panel bridge is dismantled in reverse of the order in which it was built. After dismantling, the panel bridge parts are returned to depot for reuse at another site.

b. SEQUENCE. The proper sequence of operations in dismantling a panel bridge is—

(1) Take up ramps, jack up bridge, and place rocking rollers under each end and plain rollers on near-bank assembly site.

(2) Remove end posts and assemble launching nose or counterweighted tail.

(3) Pull bridge back on near-bank plain rollers.

(4) Dismantle bridge and nose parts.

165. Replacing Bridge

While the new bridge is being constructed, some provision must be made to allow traffic to cross the gap. This can be done by building a bypass or by building the new bridge directly under the panel bridge.

a. BYPASSES. (1) Traffic can be diverted over a nearby bypass, such as a temporary bridge or culvert, while the panel bridge is being dismantled and the new bridge is being built (fig. 140).

(2) When a new two-lane bridge is being built, one lane is completed before the panel bridge is removed. This completed lane carries the traffic while the panel bridge is dismantled and the second lane is built (fig. 141).

b. NEW BRIDGE CONSTRUCTED UNDER PANEL BRIDGE. When the new bridge is built directly under the panel bridge, traffic is interrupted only for a short time while the panel bridge is dismantled and the finishing touches are added to the new bridge deck and approaches. The new bridge can be either a timber trestle or a culvert with solid fill.

(1) *Timber trestles.* Figures 142, 143, and 144 show a 110-foot TS panel bridge being replaced with timber trestle bridge. Figure 145 shows a timber trestle bridge being constructed under a panel bridge near Capua,



Figure 140. Installing metal culvert near Cavallina, Italy, as a temporary bypass while panel bridge is being dismantled and semipermanent bridge is being constructed.

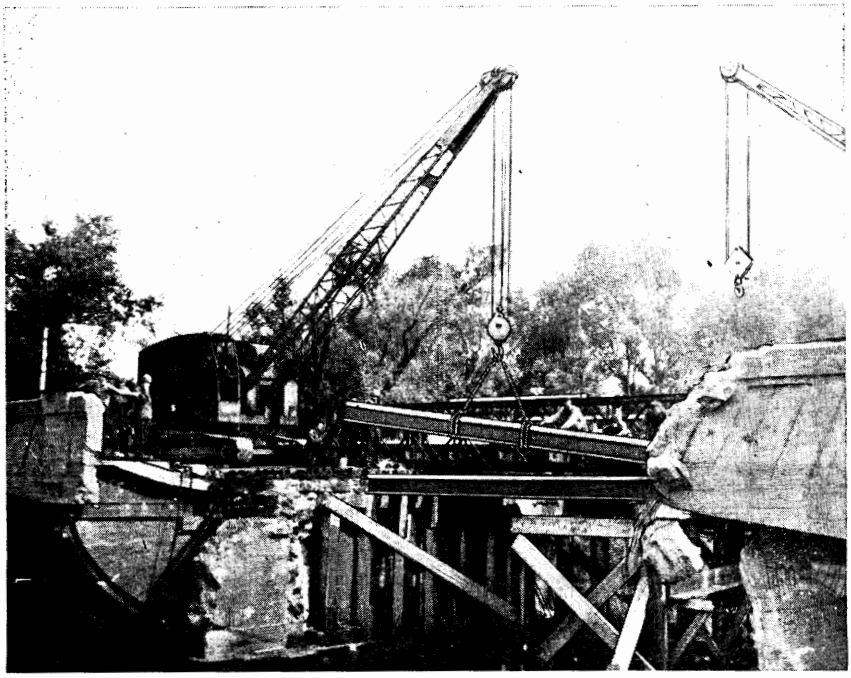


Figure 141. Construction of two-lane timber trestle bridge to replace panel bridge near Halle, Germany. When near lane is finished, traffic will be diverted over it while panel bridge is removed and second lane is completed.

Italy. At difficult sites, the panel bridge can be used as a working platform for driving piles (fig. 146) or erecting trestles.

(2) *Culverts.* Culverts can be constructed directly underneath the panel bridge and an earth fill built up to the underside of the panel bridge. This fill is compacted and surfaced after the panel bridge is removed. (See FM 5–10).

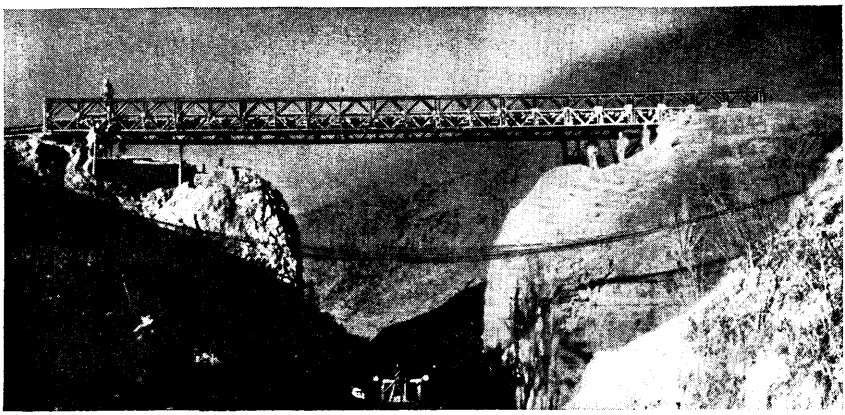


Figure 142. This 110-foot TS panel bridge over a roadway was replaced by a timber bridge with steel girders and floor beams.

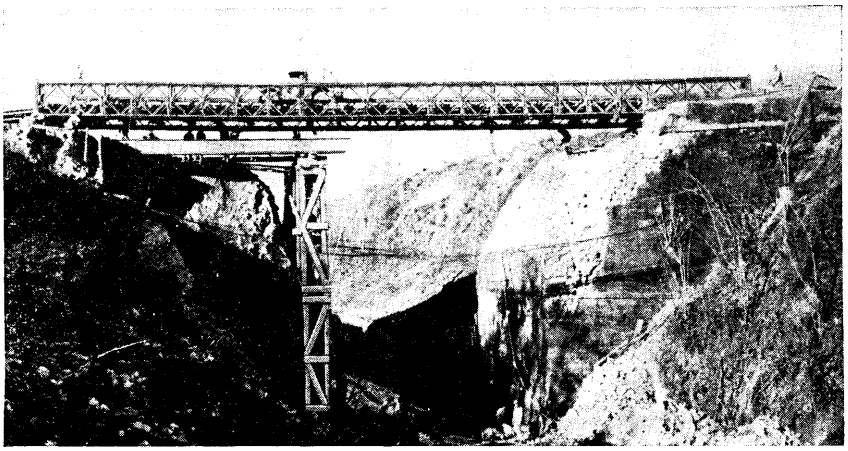


Figure 143. Beginning construction of two-lane timber trestle bridge. Work on new bridge was carried on underneath panel bridge so traffic could continue during most of the construction. Timber cribs were built on original masonry abutments. Piers were double bents, each with six 10- by 10-inch posts. Caps and sills are 12- by 12-inch timbers. Girders were 24-inch 80-pound I-beams, six per bay.

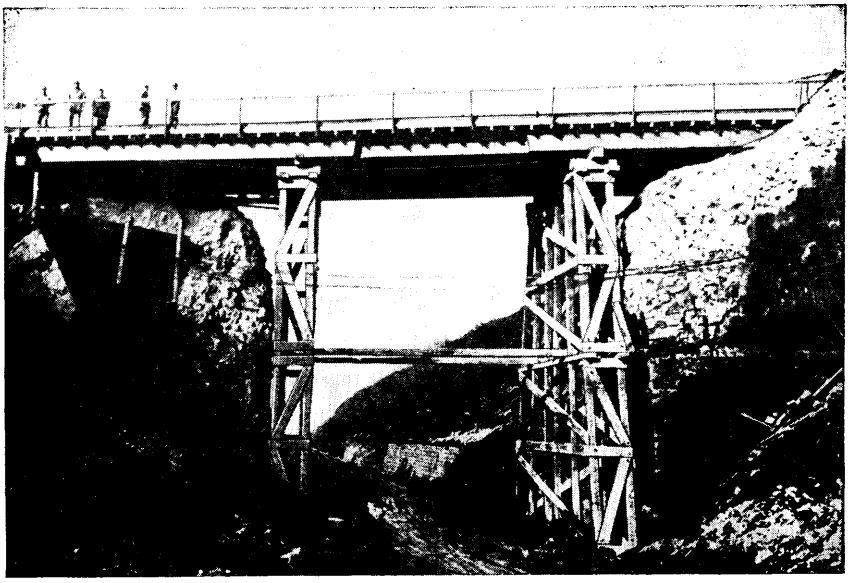


Figure 144. Traffic was interrupted while panel bridge was delaunched and flooring and guardrails added to the new bridge. Floor beams were 6-inch channels on 2-foot centers welded to girders. Decking was double layer of 3- by 12-inch planking. Two platoons of a general service regiment completed this bridge and removed 110-foot panel bridge in 16 days. New bridge was 92 feet long, 46 feet high, and had a 22-foot roadway.

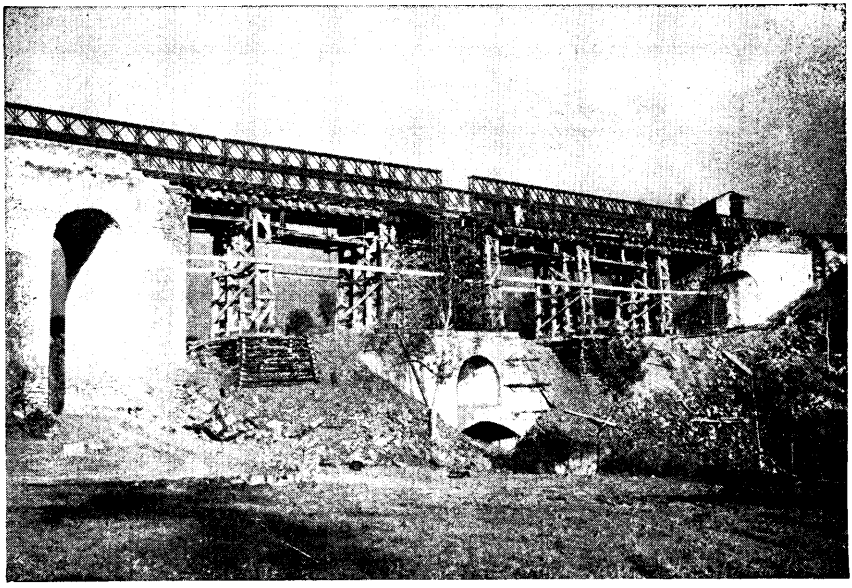


Figure 145. Construction of timber trestle bridge under panel bridge near Capua, Italy. Note hanging platforms used by men fastening floor beams.

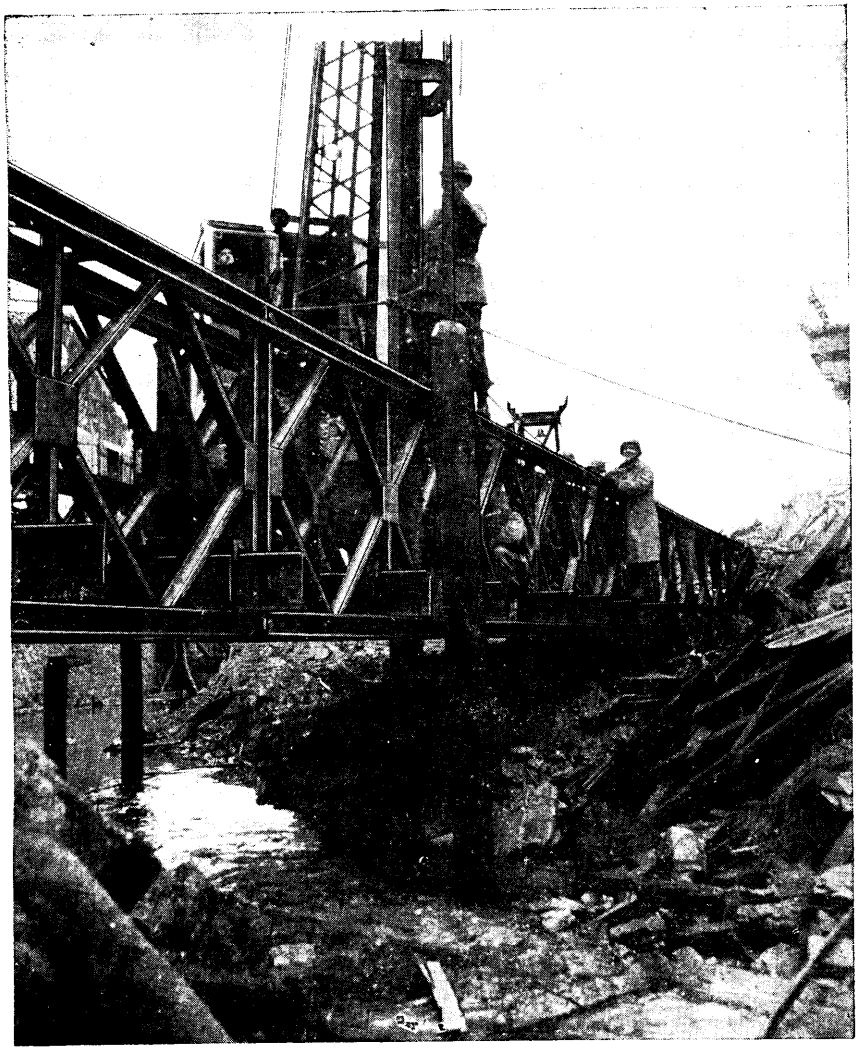


Figure 146. Using 80-foot, DS, M1 panel bridge as a construction platform for driving piles for semipermanent bridge. Note that second pile was driven between trusses. Other piles will be driven through deck after removing chess and stringers. All piles will be cut off below panel bridge so it can be dismantled.

CHAPTER 19

DEMOLITION OF BRIDGE AND PARTS

166. General

a. SCOPE. This chapter describes standard methods of demolishing panel-bridge equipment in danger of capture by the enemy. For a detailed description of available explosives and the use of demolitions see FM 5–25.

b. TRAINING. The success of these demolition methods depends on the use of a uniform procedure by all units in the theater. All ranks must be impressed with the importance of following the principles stated in this chapter.

167. Objects of Destruction

The destruction must prevent both enemy use of the bridge as a unit and use of its parts for normal or improvised construction. Destroying the equipment so its design cannot be reconstructed by enemy research is impracticable.

168. Methods of Destruction

a. To prevent use of existing bridge, cut trusses so bridge will drop into gap and destroy abutments.

b. To prevent reconstruction of a complete bridge, destroy one essential component not easily replaced or improvised. This component must be the same throughout the theater so replacements cannot be obtained from other sectors. The *panel* is the only component fulfilling these conditions.

c. To make a panel useless, remove or distort the female lug in the lower or tension chord. Destruction of both female lugs is unnecessary.

d. Always destroy *all panels first.* Certain other components such as transoms and decking useful to the enemy for improvised bridging should also be destroyed. Components, such as stringers, ramps, jacks, rollers, and erection tools, are destroyed only if time allows and explosives are available. Because the relative importance of these components varies considerably, follow the order of destruction given in par. 169.

169. Priorities

Panel-bridge equipment in danger of capture by the enemy is demolished in the following sequence:

a. DESTROY EXISTING BRIDGE. (1) *Entire bridge.* Collapse bridge by cutting the span and destroy abutment.

(2) *Individual components.* If time permits, destroy individual components in the order used for stacked equipment (*b* below).

b. DESTROY STACKED EQUIPMENT. Destroy stacks of panel-bridge equipment in the following order:

(1) Female lugs in lower chord of *all* panels.
(2) Transoms.
(3) Chess.
(4) Stringers and ramps.
(5) Jacks, rollers, and erection tools.
(6) Remaining small parts.

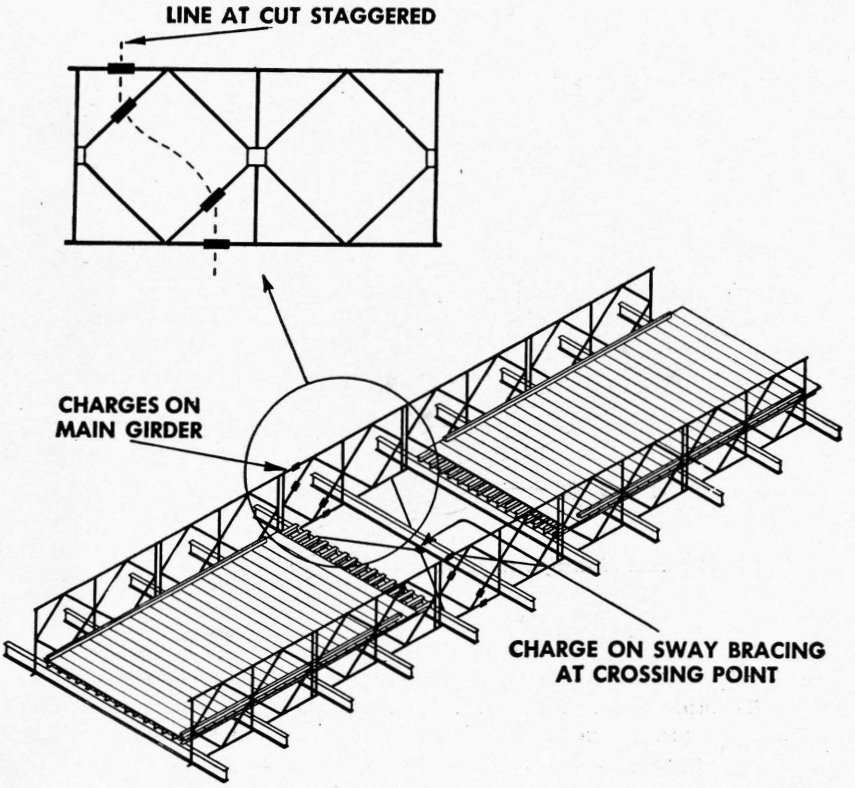


Figure 147. Destruction of assembled bridge. Placement of charges to collapse span.

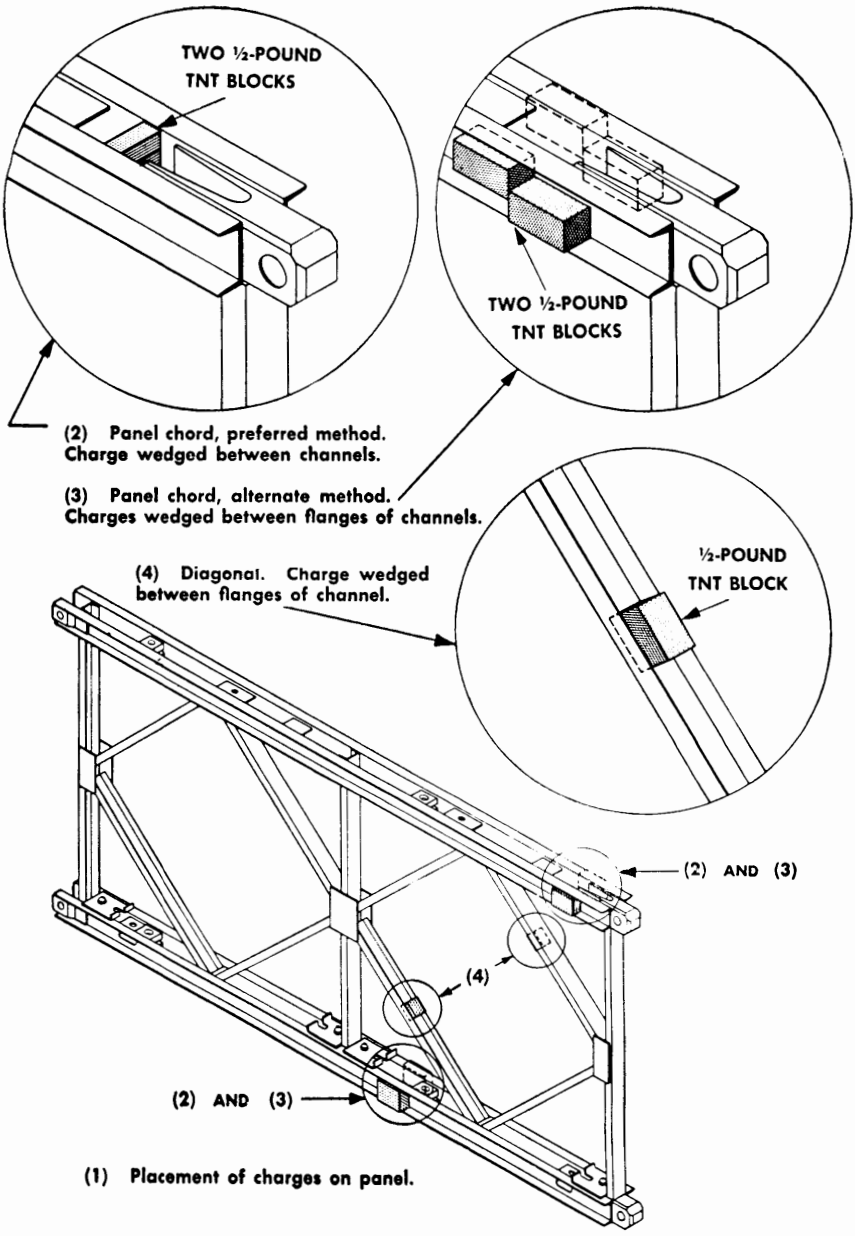


Figure 148. Destruction of assembled bridge. Placement of charges to cut panel in main girder. Wedging is not shown. For use of other explosives see table 44. (1) Placement of charges on panel. (2) Panel chord, preferred method: charge wedged between channels. (3) Panel chord, alternate method: charges wedged between flanges of channels. (4) Diagonal: charge wedged between flanges of channel.

170. Destruction of Bridge

a. Cut bridge in one or more places by cuttting panels on each side of bridge and sway braces in the same bay (fig. 147). Stagger the line of cut through the panels (see inset, fig. 147). Otherwise the top chords may jam and prevent the bridge dropping. In double- or triple-story bridges increase the charges on the chords at the junction line of the stories.

b. For further destruction, place charges on component parts of the bridge, such as panels, transoms, and stringers (figs. 148 and 149). Stack and burn decking.

c. Charges and methods of placing various explosives are given in table 44. Wedge all charges in place.

d. Use methods and charges described in FM 5–25 for destroying abutments.

171. Destruction of Stacked Equipment (Figs. 150 and 151)

a. Destroy panels and transoms in stacks. To dispose of stringers, ramps, jacks, rollers, small parts, and erection tools, dump them over large areas in places such as the sea, rivers, or woods. Burn decking.

b. Methods of destruction are described in table 45. Tamp all charges.

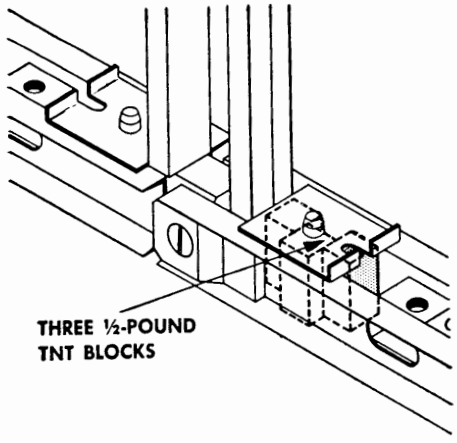


Figure 149. Destruction of parts of assembled bridge. Placement of charges to destroy lower female lugs pinned to adjoining panels. Charge wedged between channels behind end vertical at lower female lugs. Wedging is not shown. For use of other explosives see table 44.

Table 44. Destruction of Assembled Bridge and its Component Parts

Part to be cut or destroyed	Placement of charge	Figure reference	Remarks	Preferred explosive*	Charge	
				United States	Individual	Total
Destruction of Assembled Bridge		147				
Panel	.....	148(1)				
	Chords:					
	Between channels of chord	148(2)	*Preferred method*: Uses less explosive. Wedging necessary. TNT blocks require excessive wedging.	Composition C2..	1 lb	2 lb per panel.
	or					
	Between flanges of channels on each side of chord.	148(3)	*Alternate method*: For TNT blocks. Use wedging.	TNT	1 lb	4 lb per panel.
	Diagonals:					
	Between flanges of channel.	148(4)	Use wedging	TNT ..... Composition C2..	½ lb ½ lb	1 lb 1 lb } per panel.
Sway braces	At point where two braces cross.	147	Tie charge to braces.....	TNT ..... Composition C2.. Tetrytol	2 lb 2 lb 2½ lb	2 lb 2 lb } per pair braces. 2½ lb
Destruction of Parts in Assembled Bridge						
Panels lower-chord female lug (pinned to adjoining panel).	Between channels of lower chord behind end vertical.	149	Considerable wedging required with TNT blocks as they can only be inserted staggered.	TNT ..... Composition C2..	1½ lb 1½ lb	1½ lb 1½ lb } per lug.

Transoms	On web	.....	Use wedging	TNT	1 lb	1 lb } per
				Composition C2..	1 lb	1 lb } transom.
Stringers	On web of each I-beam....	.....	Put charge on each of the three I-beams in each stringer. Use wedging.	TNT	1 lb	3 lb } per
				Composition C2..	1 lb	3 lb } stringer.
Chess	.....	.....	Remove from bridge, stack, and burn (see table 45).			

* See table 46 for weight and size of packages.

Table 45. Destruction of Stacked Equipment

Part to be cut or destroyed	Placement of charge	Figure reference	Remarks	Preferred explosive*	Charge	
				United States	Individual	Total
Panels (stacked vertically or horizontally).	Between jaws of lower female lug, in alternate end panels.	150	Use wedging. TNT blocks cannot be fitted between jaws.	Composition C2.	1 lb	1 lb } per two panels
Panels (stacked horizontally only).	Between channels of lower chord behind end vertical at female lug.	149	Use wedging. Considerable wedging is required with TNT blocks as they can only be inserted staggered.	TNT ..... Composition C2.	1½ lb ..... 1½ lb	1½ lb } per two 1½ lb } panels
Transoms (stacked side-by-side).	Across top flange on an angle. and between alternate pairs of transoms at varying distances from end.	151	Use wedging ..... Blow both charges simultaneously to distort transoms and cut large pieces out of webs and top flanges.	TNT ..... Composition C2.	Enough to be laid end-to-end across top flange. 1 lb } between alternate transoms	Approximately 1 lb per transom 1 lb } per two transoms
Transoms (not stacked).	On web	.....	Use wedging	TNT ..... Composition C2.	1 lb ..... 1 lb	1 lb } per 1 lb } transom
Chess	.....	.....	Spread out, thoroughly soak with gasoline or Diesel oil and burn. Ignite by exploding two or three strands of primacord wrapped around a can of gasoline.			
Stringers, ramps, ribands, jacks, rollers, and erection tools.	.....	.....	Scatter in sea, rivers, woods, or over a large area.			

* See table 46 for weight and size of packages.

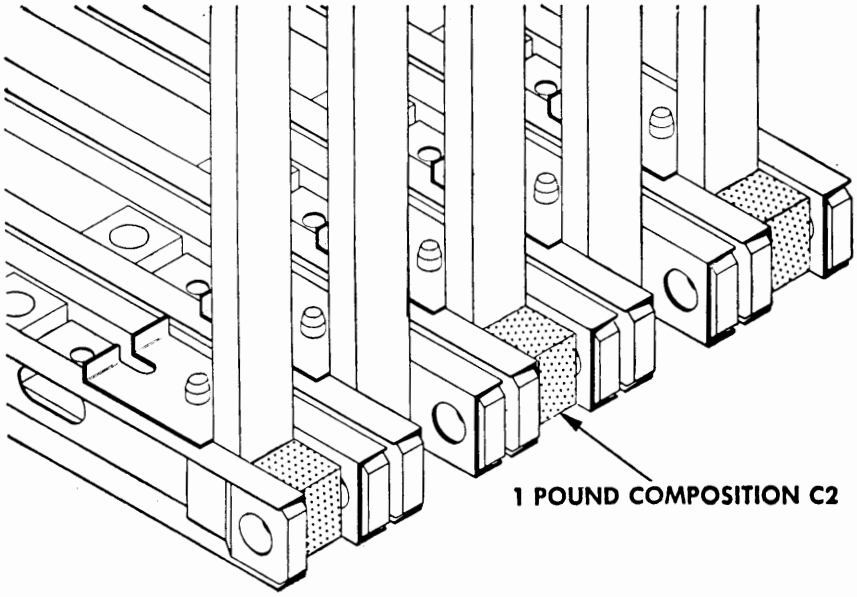


Figure 150. Destruction of stacked panels. Charge is placed between lower female lugs of alternate and end panels. Wedging is not shown. For use of other explosives see table 45.

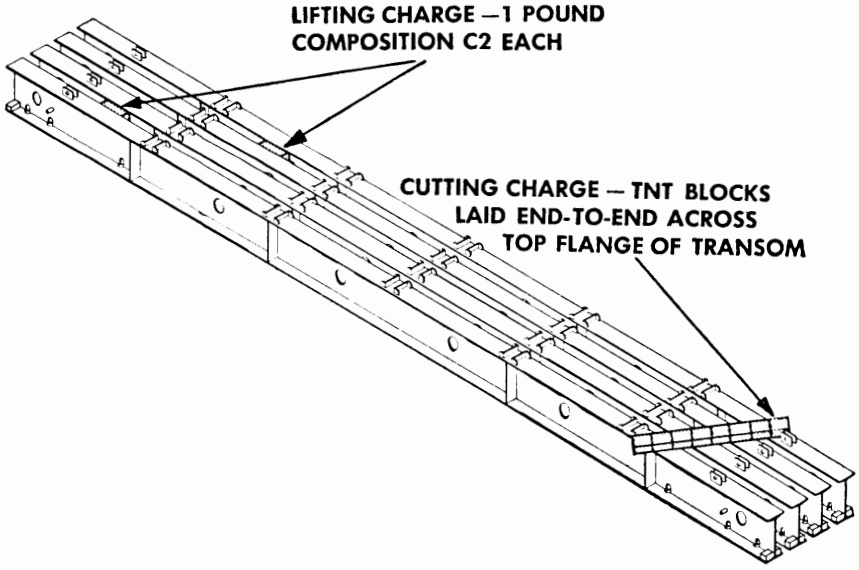


Figure 151. Destruction of stacked transoms. Lifting charge is placed between alternate transoms; cutting-charge across top flanges of transoms. Wedging is not shown. For use of other explosives see table 45.

Table 46. Weight and Size of Packages of Standard Explosives

Explosive	Weight	Package size (inches)	Remarks*
TNT	½ lb	$1^{29}/_{32}$ x $1^{29}/_{32}$ x $3^{11}/_{16}$	
	1 lb	$1^{29}/_{32}$ x $1^{29}/_{32}$ x 7.	Cap well threaded to receive standard priming adapter on firing devices.
Composition C2:			
Demolition block M3....	2¼ lb	2 x 2 x 11.....	Plastic, may be molded to any shape.
Tetrytol:			
Demolition block M1....	2½ lb	2 x 2 x 11.....	In a chain of eight blocks.
Demolition block M2....	2½ lb	2 x 2 x 11.....	Same as block M1 but not in chain. Cap well threaded to receive standard priming adapter on firing devices.
Dynamite	½ lb	1¼ dia x 8.	

* For other details see FM 5-25.

PART THREE

SPECIAL CONSTRUCTION

CHAPTER 20

TWO-LANE THROUGH TYPE BRIDGE

172. Scope and Purpose

This chapter describes the M2 fixed two-lane through type panel bridge.

a. USE. This bridge is used to provide two-way traffic where—

(1) Bridge supports at a demolished bridge are too narrow for two separate bridges (fig. 152).

(2) Narrow launching site necessitates lateral movement of separately launched bridges to position them on their bearings and, therefore, it would be easier to build a two-lane bridge.

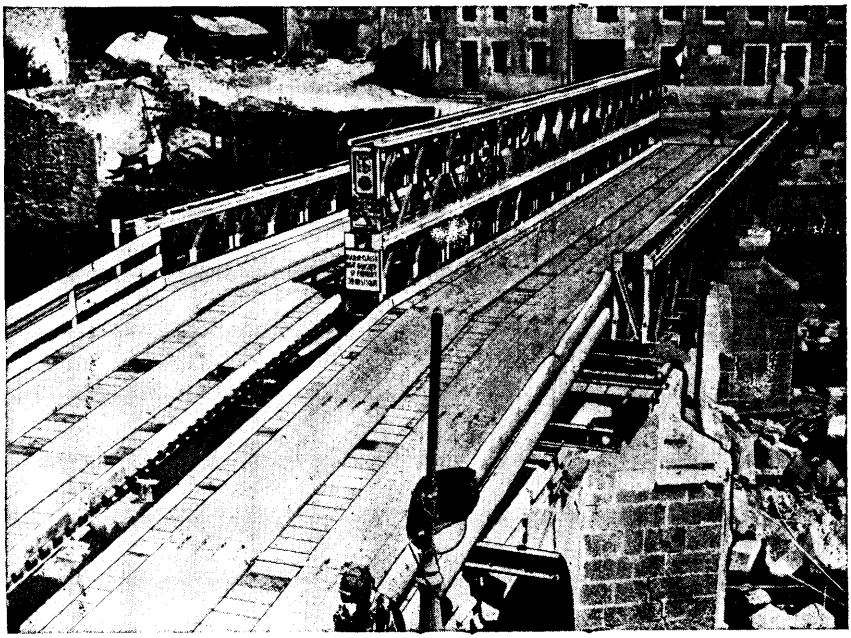
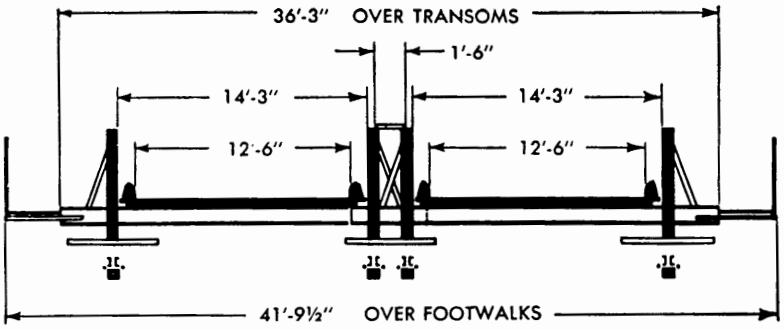
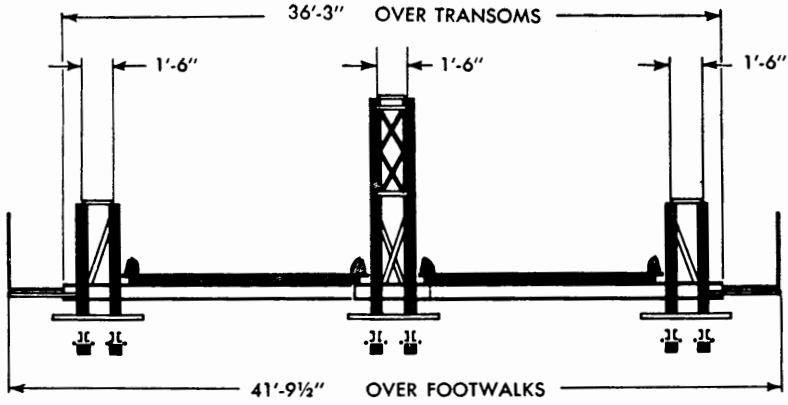


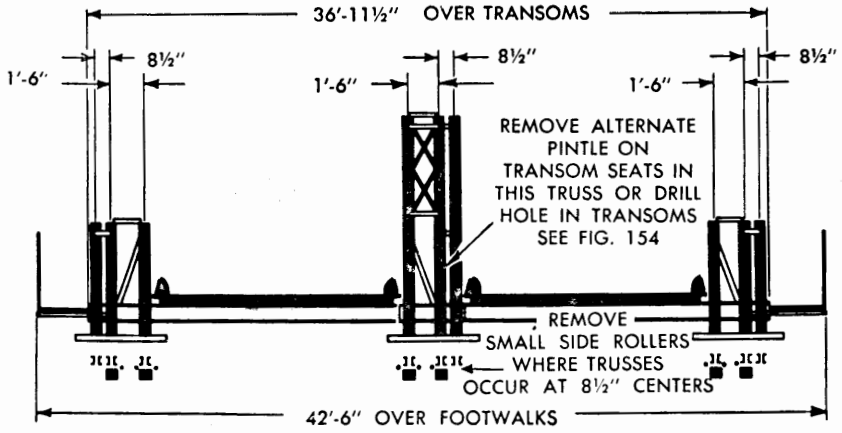
Figure 152. Two-lane panel bridge over demolished masonry arch bridge.



(1) SS-DS

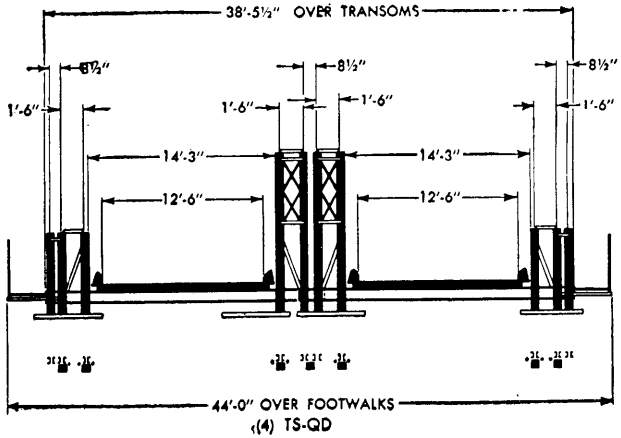


(2) DS-DD

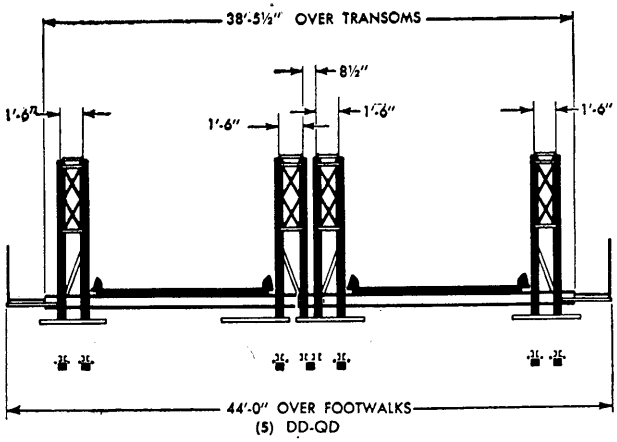


(3) TS-TD

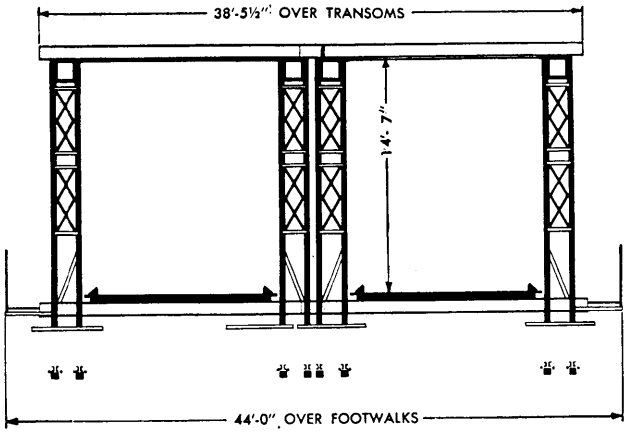
Figure 153. Two-lane bridges.



(4) TS-QD



(5) DD-QD



(6) DT-QT

Figure 153. Two-lane bridges—Continued.

b. RAFTS. On large rafts, a number of parallel panel bridge girders can be linked together to support multiple-lane decks.

c. DECK TYPE BRIDGES. For a description of two-lane deck type bridges, see chapter 21.

173. General Description

a. COMPOSITION. The bridge consists of two independent outer girders and a common middle girder, assembled from standard panel bridge parts. The middle girder carries approximately half of the total load and must be about twice as strong as the outer girders. Transoms overlap and occupy alternate transom seatings on the middle girder.

b. TYPES OF CONSTRUCTION. Only the types of construction shown in figure 153 and listed in table 47 are used. Table 47 also gives maximum spans that can be built and launched with standard equipment. Longer spans can be launched by using greased timbers or other expedients (par. 181).

Table 47. Construction, Maximum Span, and Weight per Bay of Two-Lane Panel Bridges

Type of construction		Abbreviation	Maximum span[1] (ft)	Over-all width (ft-in)	Weight per bay[2] (tons)
Outer girder	Middle girder				
		Bridge			
Single-single	Double-single	SS–DS	.....	36– 3	5.5
Double-single	Double-double	DS–DD	.....	36– 3	6.8
Triple-single	Triple-double	TS–TD	120	36–11½	8.0
Triple-single	Quadruple-double	TS–QD	140	38– 5½	8.7
Double-double	Quadruple-double	DD–QD	160	38– 5½	9.3
Double-triple	Quadruple-triple	DT–QT[3]	160	38– 5½	12.9
		Nose			
Single-single	Single-single	SS–SS			1.6
Single-single	Double-single	SS–DS			2.0
Double-single	Quadruple-single	DS–QS			3.3

[1] Limited by launching weight on rocking rollers.

[2] Fully decked and without footwalk and wear treads. Add .17 ton and .7 ton per bay for footwalks and wear treads respectively.

[3] Launched as double-story bridge.

174. Capacity

The capacity and maximum spans of two-lane bridges are the same as those of single-lane bridges with the same truss construction as the outer girders (table 48).

Table 48. Capacity and Launching Data[1]

Span (ft)	SS-DS				DS-DD				TS-TD				TS-QD				DD-QD					DT-QT[3]	Span (ft)
	Capacity (tons)	Launching weight (tons)	Sag (in)	Bays in nose SS-SS	Capacity (tons)	Launching weight (tons)	Sag (in)	Bays in nose SS-SS	Capacity (tons)	Launching weight (tons)	Sag (in)	Bays in nose SS-DS	Capacity (tons)	Launching weight (tons)	Sag (in)	Bays in nose SS-DS	Capacity (tons)	Launching weight (tons)	Sag (in)	Bays in nose		Capacity (tons)	
																				SS-DS	DS-QS		
30	40	21	4	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30
40	32	28	5	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40
50	28	33	7	3	80	40	4	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50
60	26	41	10	4	67	48	7	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60
70	22	48	14	5	64	55	9	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	70
80	18	53	18	5	51	64	14	5	80	75	13	5	80	81	13	5	.....	.....	.....	.....	.....	.....	80
90	.....	.....	.....	.....	44	72	20	6	62	85	19	6	62	91	19	6	.....	.....	.....	.....	.....	.....	90
100	.....	.....	.....	.....	31	79	23	6	52	93	22	6	52	100	22	6	75	106	17	6	.....	.....	100
110	.....	.....	.....	.....	23	87	33	7	40	103	30	7	40	111	30	7	64	118	22	7	.....	.....	110
120	.....	.....	.....	.....	18	96	45	8	34	111	34	7	34	119	34	7	50	127	24	7	.....	.....	120
130	.....	.....	.....	.....	.....	.....	.....	.....	23	121	47	8	23	130	47	8	40	138	31	8	.....	80	130
140	.....	.....	.....	.....	.....	.....	.....	.....	18	131	62	9	18	141	62	9	31	152	38	7	2	67	140
150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23	163	41	6	3	65	150
160	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	152[2]	45	7	3	56	160

[1] Launched complete except for footwalks.
[2] First seven bays of bridge undecked.
[3] Launched as double-story bridge.

175. Limitations

Two-lane through type bridges have the following limitations:

a. The maximum span that can be launched by standard launching methods is 160 feet.

b. Launching and jacking down are more difficult than for a single-lane bridge (par. 181).

176. Number of Parts and Spares

Formulas for computing the number of parts and spares required to build bridge and nose are given in table 49. The percentage of spares used for single-lane bridges is used for two-lane bridges.

177. Transportation

Standard truck loads (ch. 6) are used in transporting two-lane bridge equipment.

Table 49. Formulas for Computing Number of Parts and Spares for Two-Lane Bridges and Noses

Part	Bridge			Nose	
	Construction	Formula[1]	Spares[3]	Formula[2]	Spares[3]
Bearer, footwalk	All types	4N+2	2 or 4		
Bearing	SS-DS	8			
	DS-DD	12			
	TS-TD	12			
	TS-QD	14			
	DD-QD	14			
	DT-QT	14			
Bolt bracing	SS-DS	12N+8	25%	6n+2	25%
	DS-DD	24N+12	.....		
	TS-TD	30N+14	.....	8n	
	TS-QD	36N+20	.....		
	DD-QD	40N+24	.....	8n	
				8n+36(140′)	
				8n+52 (150′–160′)	
	DT-QT	56N+40			
Bolt, chord	DS-DD	4N	10%		
	TS-TD	6N			
	TS-QD	8N			
	DD-QD	16N			
	DT-QT	40N			

Table 49. Formulas for Computing Number of Parts and Spares for Two-Lane Bridges and Noses—Continued.

Part	Bridge			Nose	
	Construction	Formula[1]	Spares[3]	Formula[2]	Spares[3]
Bolt, end-post (spares)	All types	.....	4		
Bolt, riband, guardrail or curb	All types	.....	10%		
Bridge	.....	16N			
Ramp	.....	64			
Brace, sway					
w/o overhead bracing	All types	4N	10% to 4 max.	SS–DS and DS–DD 2n;Rest 4n	1 or 2
w/ overhead bracing	DT–QT	8N–4			
Chess	All types	.....	10% to		
Bridge	.....	26N	20 max.		
Ramp	.....	104			
Clamp, transom	SS–DS	10N	10% to	4n+2	10%
	DS–DD	14N	20 max.		
	TS–TD	21N	.....	6n+3	
	TS–QD	22N	.....	4n+2	
	DD–QD	18N	.....	4n+2	
				4n+19(140′)	
				4n+25(150′–160′)	
	DT–QT	18N			
Footwalk	All types	2N	2		
Frame, bracing	SS–DS	N	10%		1 or 2
	DS–DD	4N+1			
	TS–TD	4N+1			
	TS–QD	6N+2			
	DD–QD	8N+4			
				9(140′)	
				13(150′–160′)	
	DT–QT	12N+8			
Panel	SS–DS	4N	10% to	3n	10%
	DS–DD	8N	10 max.		
	TS–TD	12N	.....	4n	
	TS–QD	14N	.....		
	DD–QD	16N	.....	4n	
				4n+8(140′)	
				4n+12(150′–160′)	
	DT–QT	24N			
Pedestal, ramp	All types	16			
Pin, panel	SS–DS	8N+8	20% to	6n–6	20%
	DS–DD	16N+12	50 max.		
Pin, safety	TS–TD	24N+18	25% to	8n–8	25%
	TS–QD	28N+20	70 max.		
	DD–QD	32N+16	.....	8n–8	
				8n(140′)	
				8N+8(150′–160′)	
	DT–QT	48N			

Table 49. Formulas for Computing Number of Parts and Spares for Two-Lane Bridges and Noses—Continued.

Part	Bridge			Nose	
	Construction	Formula[1]	Spares[3]	Formula[2]	Spares[3]
Pin, sway-brace (spares).	All types	.....	12	.....	20% to 30%
Plate, base.....	SS–DS	6			
	DS–DD	6			
	TS–TD	6			
	TS–QD	8			
	DD–QD	8			
	DT–QT	8			
Plate, tie.....	TS-TD	4N+2	10%		
	TS–QD	2N+2			
Post, end, female....	SS–DS	4	2		
Post, end, male.....	DS–DD	6	2		
	TS–TD	9			
	TS–QD	10			
	DD–QD	8			
	DT–QT	8			
Post, footwalk.....	All types	4N+2	10% to 4 max.		
Raker.....	SS–DS	4N+4	10%	3n+1	2
	DS–DD	4N+4	.....		
	TS–TD	3N+3	.....		
	TS–QD	4N+4	.....	4n	
	DD–QD	4N+4	.....		
	DT–QT	4N+4			
Ramp, button.....	All types	16			
Ramp, plain.....	All types	32			
Riband, guardrail or curb.	All types				
Bridge.....	.....	4N			
Ramp.....	.....	16			
Stringer, button.....	All types	4N	10%		
Stringer, plain.....	All types	8N	10% to 4 max.		
Support, bracing, overhead.	DT–QT	4N	10% to 4 max.		
Transom				SS–DS, DS–DD, TS–TD, TS–QD: 2n+1...	1
Bridge					
w/o overhead bracing	All types	4N+2	10% to 4 max.		
w/overhead bracing	DT–QT	6N+2	.....	DD–QD 2n+1	
Ramp.....	All types	4	.....	2n+2(140′–160′)	

[1] N = Number of bays in bridge.
[2] n = Number of bays in nose (see table 48).
[3] Spares are not included in formulas and must be added.

178. Construction Details

The following construction details show how two-lane bridge construction differs from single-lane construction:

a. Transom Seating in TS-TD Bridges. The spacing of trusses in the girders of TS-TD bridges is normal with respect to one lane. With respect to the other lane, however, the two middle-girder trusses nearest that lane are spaced at 8½ inches instead of 1 foot 6 inches. Accordingly, transoms from that lane do not fit on seating pintles of the center truss; these pintles must be removed or transoms drilled (fig. 154).

b. Ramp Clearance. To provide clearance between transoms and ramps at the ends of SS-DS and DS-DD bridges a 3½- by 4½-inch notch is cut in transoms seated on the end posts and the ramp transoms are offset 2¼ inches from the bridge center line (fig. 155).

c. Launching Nose. The length and construction of launching noses for two-lane bridges are given in table 48.

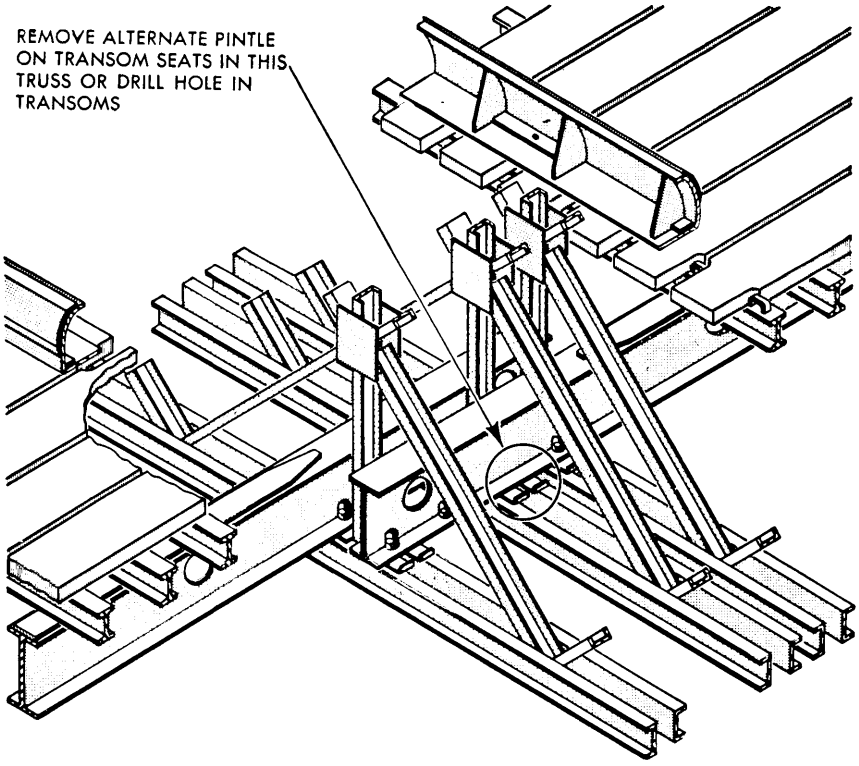


Figure 154. Transom seating in TS-TD bridges.

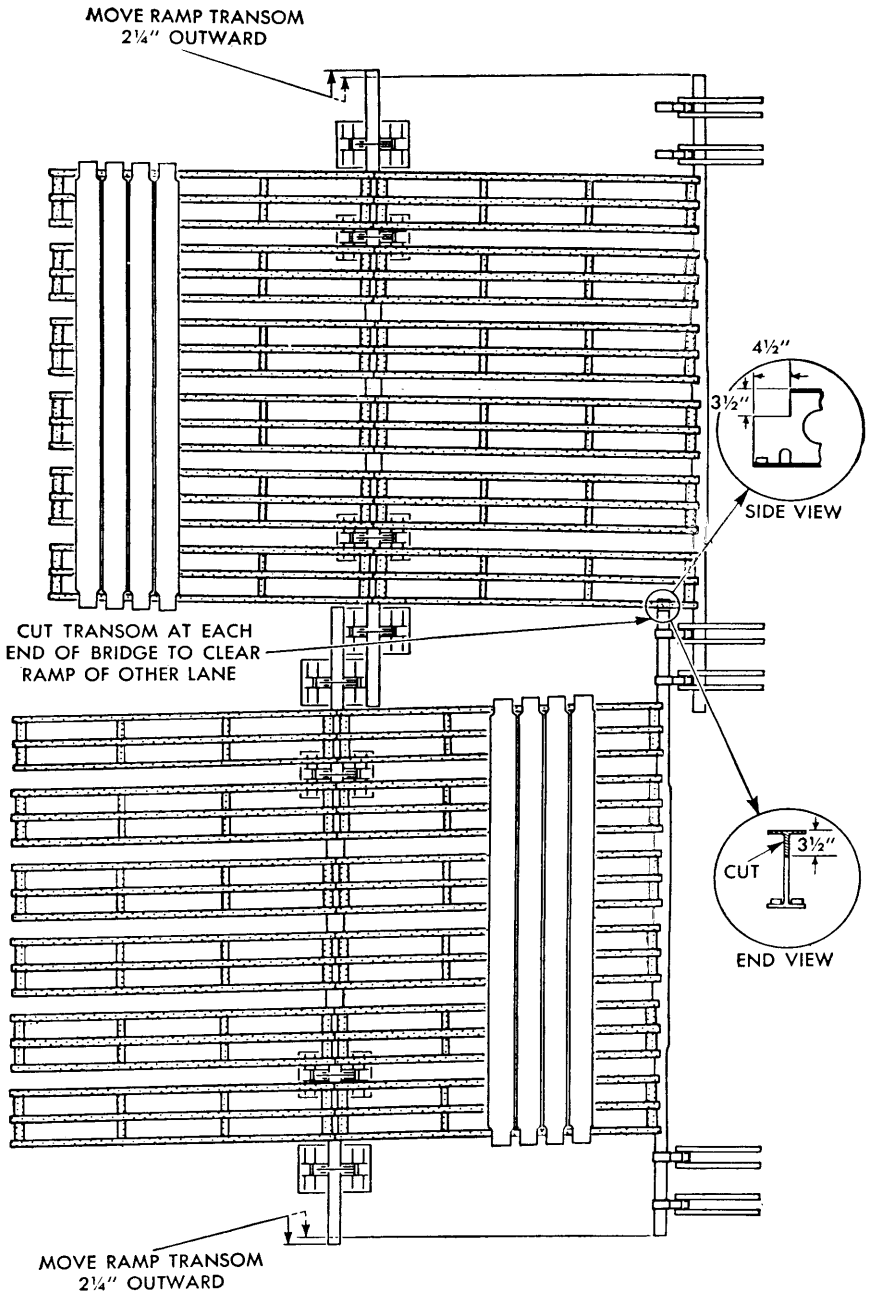


Figure 155. Ramp clearance for SS-DS and DS-DD bridges.

(1) *SS-DS and DS-DD bridges.* Noses for SS-DS and DS-DD bridges consist of three SS trusses. One completely braced nose of the required length is built for one lane. For the second lane, a single truss is added and connected to the middle truss by transoms overlapping the transoms of the first lane. Rakers are added to second lane but sway bracing is omitted (fig. 156).

(2) *TS-TD, TS-QD, and DD-QD bridges.* Noses for TS-TD, TS-QD, and DD-QD bridges normally consist of SS outer girders and two SS middle girders (fig. 157). However, all girders in the last two nose bays of the 140-foot DD-QD and the last three nose bays of the 150- and 160-foot DD-QD bridges are double-truss construction. In all cases, transoms are placed in alternate seatings and the nose is braced the same as for normal construction. Transoms connect the nose girders of the TS-TD bridge. However, the nose girders of the TS-QD and DD-QD bridges cannot be connected because transoms are not long enough except in DS-QS nose bays.

179. Working Parties and Construction Time

a. SINGLE-LANE-BRIDGE CONSTRUCTION PARTY. With the same party organization as for single-lane bridges, construction time for a two-lane bridge is slightly more than double the construction time for single-lane bridge.

b. SPECIAL ORGANIZATION. With a specially organized crew (table 50), construction time for a two-lane bridge is slightly less than double the construction time for single-lane bridge.

Table 50. Suggested Organization of Assembly Parties

Party	Number of NCO's and EM for various type bridges				
	SS-DS	DS-DD	TS-TD	TD-QD	DD-QD
Panel	2-28	2-28	2-48	2-54	3-64
Carry	(24)	(24)	(42)	(48)	(56)
Pin	(4)	(4)	(6)	(6)	(8)
Transom	2-18	2-18	2-20	2-20	2-20
Carry	(16)	(16)	(16)	(16)	(16)
Clamp	(2)	(2)	(4)	(4)	(4)
Bracing	2-14	2-18	2-21	2-26	2-28
Sway brace	(6)	(6)	(6)	(6)	(6)
Raker	(2)	(4)	(4)	(8)	(10)
Bracing frame	.....	(2)	(2)	(4)	(6)
Chord bolt	.....	.....	(3)	(2)	.....
Tie plate	.....	.....	2-20	2-20	2-20
Decking	2-20	2-20	(12)	(12)	(12)
Stringer	(12)	(12)	(8)	(8)	(8)
Chess and riband	(8)	(8)	8-109	8-120	9-132
TOTAL	8-80	8-84			

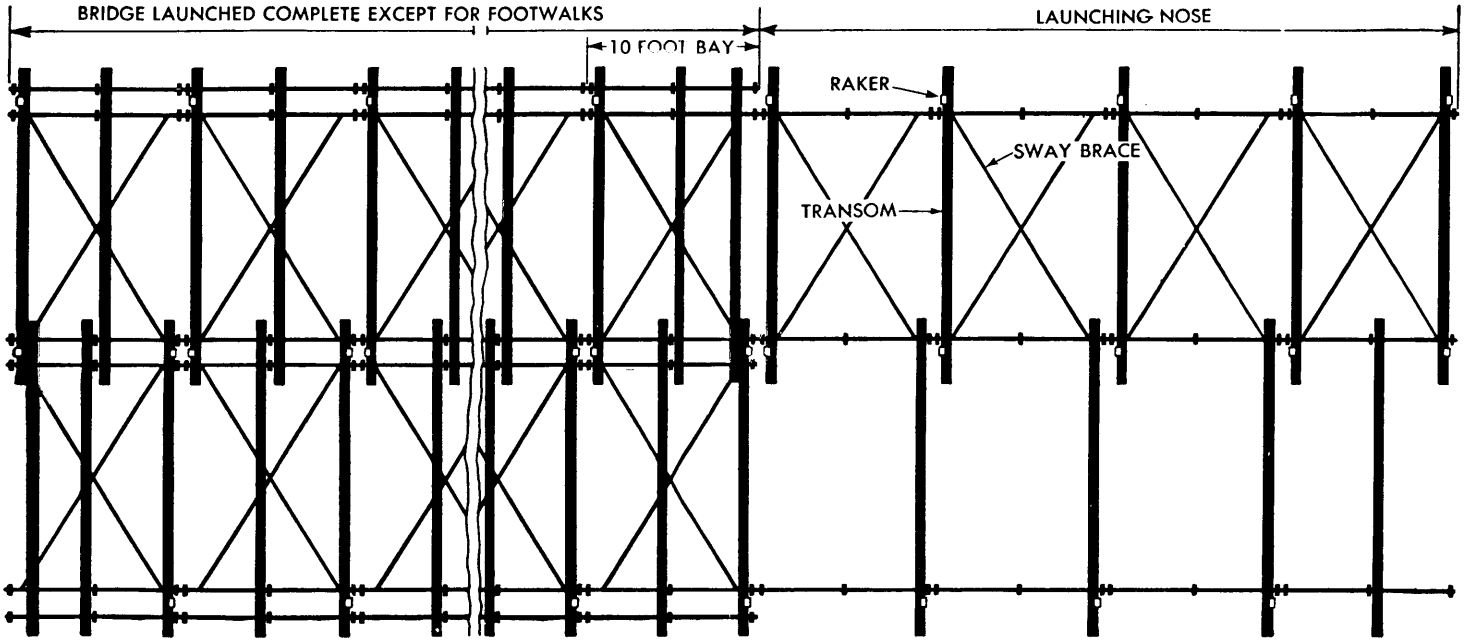


Figure 156. Typical launching nose for SS-DS and DS-DD bridges.

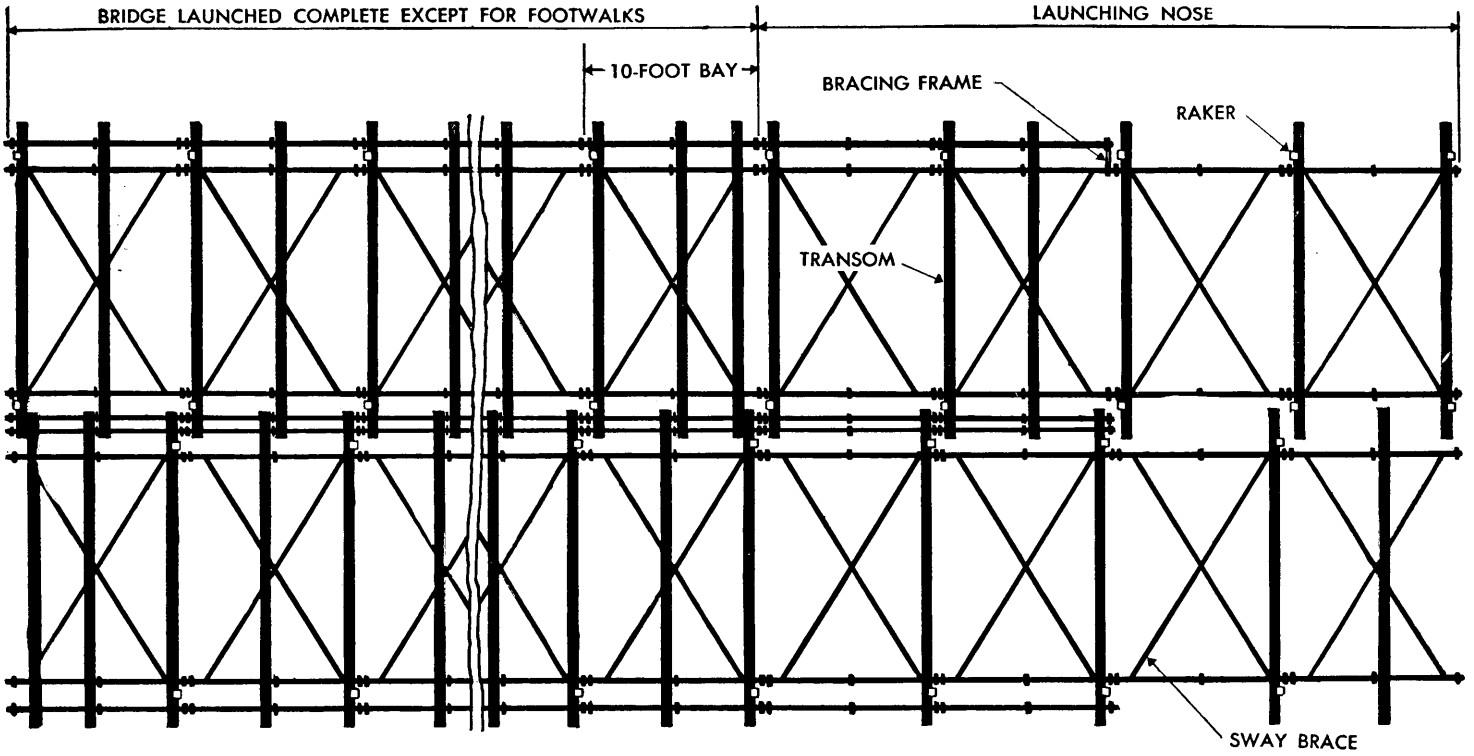


Figure 157. Typical launching nose for 140-, 150-, and 160-foot DD-QD bridges. Launching nose for TS-TD, TS-QD, and the remainder of DD-QD bridges is similar with extra transom and two bays of DS-QS construction omitted.

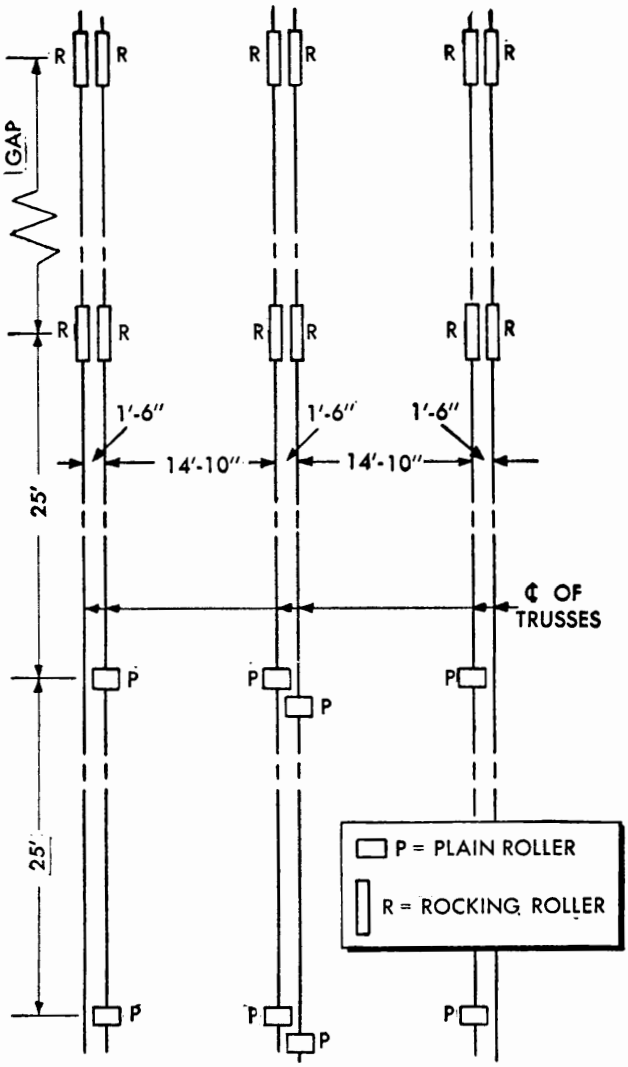


Figure 158. Typical roller lay-out showing plain rollers staggered under middle girder.

c. Unloading and Security Details. Unloading and security details are the same as for a single-lane bridge.

180. Roller Lay-out

Figure 153 shows lateral spacing of rocking rollers for various types of bridge construction. Roller loads for outer girders are the same as for single-lane bridges. However, since roller loads for the middle girder are approximately double, enough plain rollers must be used under this girder to prevent overloading them. These plain rollers must be staggered

to provide clearance between them (fig. 158). Chapter 9 describes the method of using a transom to position bearings for rocking rollers. Rollers must be alined both horizontally and vertically. Rocking rollers are used on the far bank for all bridges except SS-DS, where plain rollers may be used.

181. Assembly and Launching

Methods of assembling and launching the two-lane bridge are the same for both the single-lane construction party and the special organization given in table 50.

a. Assembling SS–DS and DS–DD Bridges. (1) Build one lane of launching nose with sway bracing in every bay, using launching links if necessary. Place one transom behind forward upright of panel in first bay and one transom in front of rear upright of panel at each joint. Fix rakers at each joint.

(2) Add third truss for other lane, using launching links if necessary. Place one transom for second lane of nose in front of middle upright of panel in first bay and one transom behind upright of panel at each joint. Fix rakers at each joint.

(3) Assemble bridge the same as for single-lane bridge construction, keeping panels in one lane one bay ahead of panels in other lane. Attach all bracing frames as for a single-lane bridge.

b. Assembling TS-TD, TS-QD, and DD-QD Bridges. Assemble bridge the same as for single-lane construction, keeping panels in one lane one bay ahead of panels in other lane. For double- and triple-truss middle girders, attach bracing frames, tie plates, and rakers as in single-lane bridge construction. When middle girder is quadruple-truss construction, do not use tie plates between center trusses; use full number of bracing frames and rakers (fig. 153).

c. Assembling DT-QT Bridge. Assemble the DT-QT bridge the same way as for the DD-QD bridge. However, when using overhead bracing supports in both lanes, make sure female panel lugs in one lane face in opposite direction to female lugs in other lane. This prevents interference between overlapping transoms.

d. Launching. Table 48 gives the launching weight for each type of construction. The lighter bridges listed in the table can be launched by single-lane launching methods. For heavier bridges, vehicles with winches can be used to aid in launching. Care must be taken to prevent overloading rollers and to keep the balance point of bridge and nose behind the near-shore rocking rollers. Spans longer than those listed in table 47 can be launched by—

(1) Skidding the bridge over greased timbers to give more bearing along the lower chord of the girders. The bridge load, however, must not exceed the crushing strength of timber.

(2) Launching the bridge in skeleton form so the allowable load on the rollers is not exceeded.

(3) Using special rocking distributing beam for mounting two rocking rollers in line under each truss.

Table 51. Maximum length of continuous-span two-lane bridge that can be jacked over intermediate pier with jacks arranged as in (1), Figure 214[1]

Construction of span	Maximum lengths of two spans of continuous bridge over intermediate piers							
		Two jacks under trusses at center and each side of bridge			Four jacks under trusses at center and each side of bridge			
SS-DS	Short span	0–35	40–55	57.5	0–45	50–80		
	Long span	[2]	60	57.5	[2]	80		
DS-DD	Short span	0–40	45–50	55–65	0–70	75–120		
	Long span	[2]	70	65	[2]	120		
TS-TD	Short span	.....	.....	.....	0–70	75–85	90–100	105–110
	Long span	.....	.....	.....	[2]	120	115	110
TS-QD	Short span	.....	.....	.....	0–60	65–80	85–95	97.5
	Long span	.....	.....	.....	[2]	105	100	97.5
DD-QD	Short span	.....	.....	.....	0–65	70–85	90–100	102.5
	Long span	.....	.....	.....	[2]	110	105	102.5

[1] Based on dead weight of two spans of same construction over intermediate pier.
[2] Length of long span cannot exceed 167% of short span.

Table 52. Maximum length of continuous-span two-lane bridge that can be jacked over intermediate pier with jacks arranged as in (2), Figure 214[1]

Construction of span	Maximum lengths of two spans of continuous bridge over intermediate piers								
		Six jacks under trusses at center and each side of bridge				Twelve jacks under trusses at center and each side of bridge			
SS-DS	Short span	0–45	50–80	.....	.....	0–45	50–80		
	Long span	[2]	80	.....	.....	[2]	80		
DS-DD	Short span	0–60	65–80	85–95	97.5	0–70	75–120		
	Long span	[2]	105	100	97.5	[2]	120		
TS-TD	Short span	0–50	55–65	70–80	82.5	0–80	85–140		
	Long span	[2]	90	85	82.5	[2]	140		
TS-QD	Short span	.....	.....	.....	.....	0–70	75–85	90–100	105–115
	Long span	.....	.....	.....	.....	[2]	125	120	115
DD-QD	Short span	.....	.....	.....	.....	0–75	80–90	95–105	110–120
	Long span	.....	.....	.....	.....	[2]	130	125	120

[1] Based on dead weight of two spans of same construction over intermediate pier.
[2] Length of long span cannot exceed 167% of short span.

e. JACKING. (1) *Single-span two-lane bridges.* Jacking of single-span two-lane bridges is done the same way as for single-lane bridges.

(2) *Bridges on piers.* See paragraph 218. Tables 51 and 52 give maximum lengths of adjacent spans of continuous-span two-lane bridges that can be jacked over intermediate piers with jacks arranged as shown in figure 214.

182. Reinforced Two-Lane Bridges

Two-lane bridges are reinforced by adding trusses or stories using the same methods as for single-lane bridges (see ch. 11, sec. VII, and ch. 12, sec. VI). Normally, reinforcement of only one lane is necessary.

a. TRUSS CONSTRUCTION. Table 53 gives the truss construction of reinforced two-lane bridges.

Table 53. Equivalent Simple Span Construction for Reinforced Lane of a Two-Lane Bridge

Existing bridge	Method of reinforcing		Equivalent reinforced lane construction	
	Outer girder	Middle girder	Normal lane closed to traffic	Both lanes open to traffic
SS–DS	Add one truss.....	.....	DS	SS
	Add one truss.....	Add double truss second story.	DS	DS
DS–DD	Add double truss second story.	.....	DD	DS
	Add double truss second story.	Undersling double truss third story.	DD	DD
TS–TD	Add triple truss second story.	.....	TD	TS
	Add triple truss second story.	Undersling triple truss third story.	TD	TD
TS–QD	Add double truss second story.	.....	DD	DD
	Add double truss second and third story and overhead bracing.	Add double truss third story and overhead bracing.	DT	DT
DD–QD	Add double truss third story and overhead bracing.	Add double truss third story and overhead bracing.	DT	DT

b. METHODS OF REINFORCING. Stories can be added to the top of the existing girders or they can be underslung. However, when the middle girder is reinforced to triple-story, the panels must be underslung unless the reinforced outer girder is also triple-story; otherwise, overhead bracing cannot be installed.

(1) *Reinforcing one outer girder.* One lane of a two-lane bridge can be reinforced by reinforcing one outer girder. However, the reinforced lane has the capacity of a single-lane bridge of the same construction as the reinforced outer girder only when the normal lane is closed to traffic.

(2) *Reinforcing one outer girder and middle girder.* When both the outer and middle girder are reinforced, the reinforced lane has the same capacity as a single-lane bridge of the same construction as the reinforced outer girder without closing the normal lane to traffic.

183. Conversion of Single-Lane Bridges to Two-Lane Bridges

To convert a single-lane bridge to a two-lane bridge without closing the bridge to traffic for a long period, take the following steps:

a. If two-lane bridge is to be centered on old bridge center line, proceed as follows:

(1) Remove approach ramps on each bank and jack bridge up. Lay transom on three plain rollers on each bank perpendicular to bridge

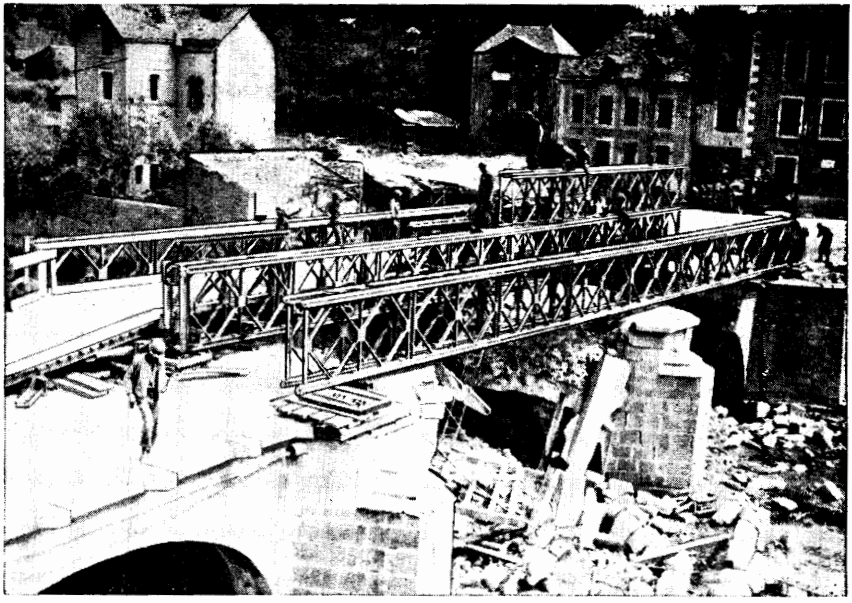


Figure 159. Converting single-lane bridge to two-lane bridge using single-girder method for launching outer girder in second lane. Note single lane open to traffic during construction.

center line, so raker lugs come directly under spaces between girders of end bays. Extra bays are added to the bridge where insufficient working space on bank is available before transoms are placed.

(2) Jack bridge down on the transoms resting on the rollers and move bridge sideways to new position.

(3) Prepare new bank seats and position grillage. Center grillage must be twice the width of the outer grillage.

(4) Position bearings for the bridge in its new location. Bearings are placed under original end span or extra span depending on bank conditions. Jack bridge onto bearings.

(5) Place ramps and open bridge to traffic (fig. 159).

(6) Position rollers for third girder and launch by single-girder method (fig. 159). See chapter 29 for launching by single-girders. The third girder can also be launched by using a truck crane on deck of existing bridge.

(7) Connect third girder to rest of bridge with transoms. If available, use a truck crane to place transoms. If a truck crane is not available or if sag is great, add second story to middle girder before connecting third girder with transoms.

(8) Add second story to middle girder.

(9) Deck second lane.

b. If existing bridge is to remain in position, proceed as follows:

(1) Jack bridge up and double grillage area under center girder. Jack bridge down. If bridge is to be lengthened, add extra bays and locate bearings and grillage in new position.

(2) Proceed as for two-lane bridge (see *a* above).

CHAPTER 21

DECK TYPE BRIDGES

184. Scope

This chapter describes the use of panel bridge equipment to build fixed deck-type highway bridges. The use of panel bridge parts for railway bridges is described in chapter 22.

185. Use

Deck type panel bridges (figs. 160 and 161) are normally two-lane, class 50 or higher, line-of-communications bridges constructed to replace weaker single-lane tactical bridges.

a. ADVANTAGES. Deck type panel bridges have the following advantages over through type bridges:

(1) Roadway can be wider for passage of extra-wide vehicles.

(2) Deck-type construction allows greater side overhang of vehicles.

(3) A lighter floor system can be used with roadway directly supported by trusses.



Figure 160. Two-lane, 1370-foot, deck type panel bridge over the Po River at Ostiglia, Italy. The 18 trusses carried two-way class 55 loads, and one-way class 100 loads. Maximum span between piers is 100 feet.

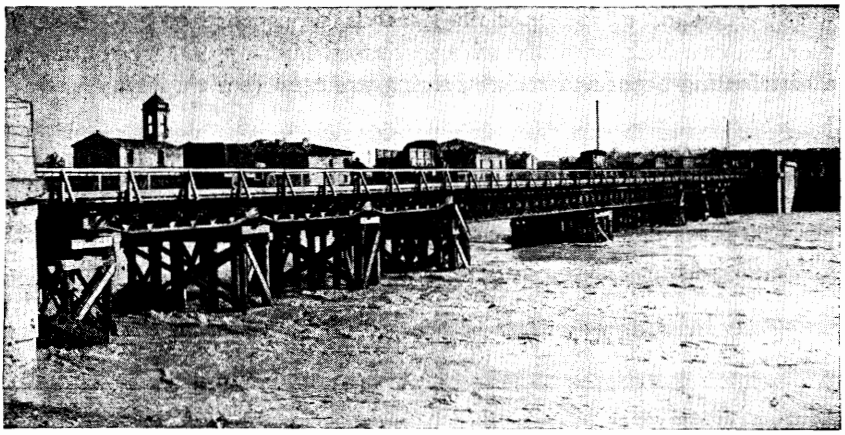


Figure 161. Two-lane deck type panel bridge over Arno River at Pisa, Italy. Two 85-foot center spans are made from 10-panel bridge trusses continuous over the center pier.

(4) With some sloping banks, the span between abutments is shorter than in a through type bridge because bearings are set 5 feet below road level.

(5) Demolished piers need not be built up to level of roadway.

b. DISADVANTAGES. Deck type panel bridges have the following disadvantages:

(1) Excavation at abutments may be necessary because bearings are 5 feet below the roadway.

(2) Bridge is more difficult to launch.

(3) Bridge must be lowered 5 feet onto the bearings.

(4) Waterway clearance is decreased.

186. Standard Design Bridges

a. TRUSSES. The trusses are grouped into three-truss girders, which are spaced evenly under the roadway. The trusses may be single- or double-story construction.

b. BRACING. Bracing frames are used to tie trusses of each girder together as shown in figure 163. Every two bays are cross braced by angles welded diagonally across the bottom chords of all trusses. The floor system serves as top lateral bracing.

c. FLOOR SYSTEM. The floor system is made from standard panel bridge parts (transoms, stringers, and chess) or timber.

d. BEARINGS. (1) *End bearings.* End posts attached to top story panels may be rested on standard panel bridge bearings. In multi-story construction, the end panels of the lower stories are omitted to allow room for the abutment. If end posts are not used, the trusses rest on timber blocking or a rocker bearing under the joint between the first and second bay from each end.

(2) *Bearings at intermediate piers.* If the spans are broken at the pier, the two ends are fitted with end posts. If the spans are continuous, a distributing beam and rocker bearing are used (see ch. 24).

187. Capacity

Standard deck type panel bridges have been designed to carry two-way class 50 loads and one-way class 80 loads. Table 54 lists the maximum spans of these bridges.

Table 54. Maximum Spans of Standard-Design Two-Lane Deck Type Panel Bridges

Number of stories	Number of trusses	Type of deck	Total road width (inches)		Capacity (tons)		Maximum span (ft)
			One lane	Two lane	Two way	One way	
1	15	M2 transoms, stringers, and chess.	150	316	50	80	120
1	15	Timber	130	272	50	80	120
2	15	M2 transoms, stringers, and chess.	150	316	50	80	170
2	15	Timber	130	272	50	80	160

188. Equipment

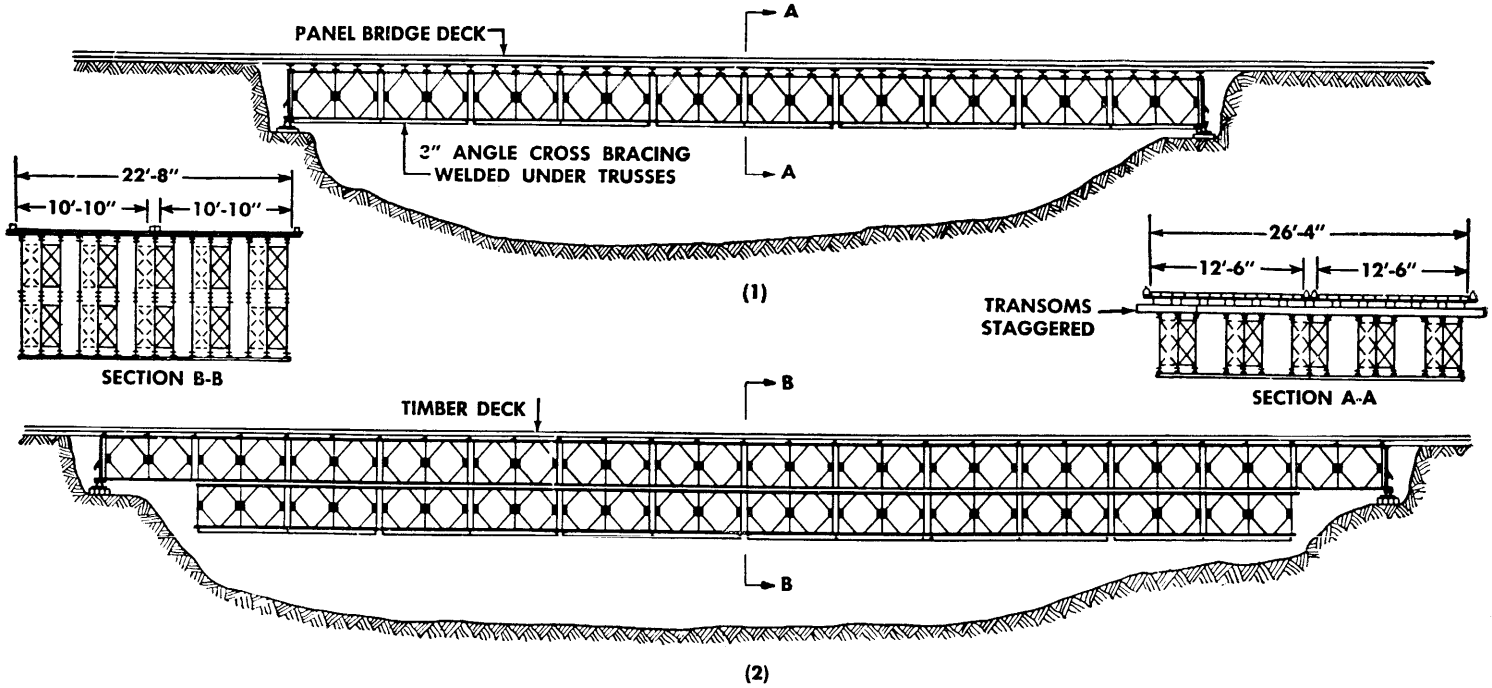
Table 55 lists the material required to build end and interior bays of standard-design deck type panel bridges (fig. 162).

189. Construction

a. STANDARD CONSTRUCTION. (1) *Trusses.* The most practical load distribution is obtained by spacing the trusses uniformly under a relatively stiff deck. Five 3-truss girders (15 trusses) are used under the bridge deck. Trusses in each girder are spaced 1 foot 6 inches apart and tied together with bracing frames (fig. 163). Girders are spaced 4 feet 6 inches on centers under the 22-foot deck using 12-foot timbers (figs. 164 and 165) and 5 feet 6 inches on centers under the 26-foot deck using M2 chess (fig. 163).

(2) *Bracing.* (*a*) *Bracing frames.* Bracing frames are used as much as possible at panel junctions to space the trusses and to provide lateral stability in each three-truss girder.

(*b*) *Angles.* Three- by three-inch angles are welded diagonally across the bottom chords of each two bays to brace and tie the five 3-truss girders together. Welding must be done carefully so the properties of the



① *Single-story bridge with panel bridge deck.*
② *Double-story bridge with timber deck.*

Figure 162. Standard two-lane, deck type, panel bridges.

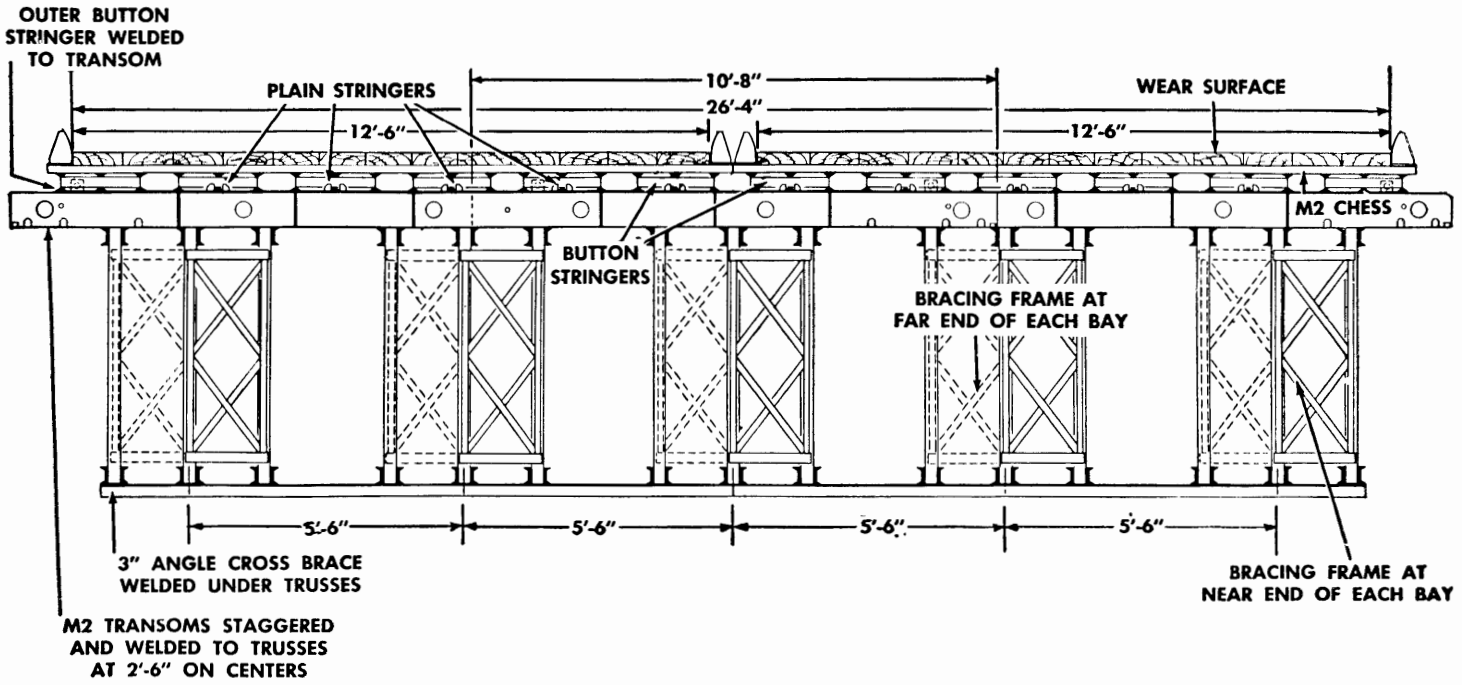


Figure 163. Details of standard M2 panel bridge deck on two-lane deck type panel bridge.

high tensile steel in the panel bridge parts are not changed. Mild steel bracing members should be used, and they should be welded in place before any loads are applied to the bridge.

(3) *Floor systems* (*a*) *Panel bridge decking* (figs. 163 and 348). Transoms and chess are used. Transoms at 2-foot 6-inch intervals are welded to the top chords of the trusses and staggered so the end stringer lug of one transom is alined with the second stringer lug on the adjacent transom. Standard stringers are seated between the stringer lugs on the transoms with two rows of button stringers down the center line of the bridge. Raker lugs are removed from the transoms and an outer row of button stringers is welded to the transoms outside of the plain stringers. Chess are then laid on the stringers and fastened down by ribands. A minimum of two inches of timber wear surface, preferably diagonal, is nailed over the chess. The total road width is the length of two chess. A curb is placed down the center at the junction of the two chess. With M2 chess, the total clear width is 26 feet 4 inches (two 12-foot 6-inch lanes with a 1-foot 4-inch center curb) (fig. 163).

(*b*) *Timber decking.* Before the timber decking is laid, 3-inch angles are welded transversely to the top chords of the trusses at 5-foot centers. These angles tie the trusses together and provide a brace for clamping the riband bolts. The timber flooring can be laminated or laid in two layers.

1. Laminated flooring (fig. 164). Laminated flooring is better than layered flooring because the nails cannot work out under traffic vibration, thereby reducing maintenance. The three- by six-inch timbers are laid on edge perpendicular to the long axis of the bridge and nailed together horizontally. For ease of construction $2\frac{1}{2}$-foot sections of laminated floor can be prefabricated beforehand and then two sections are laid between each pair of angles. The end timber of each section is notched to fit over the horizontal legs of the angles. Wood ribands are laid over the floor and $\frac{3}{4}$-inch riband bolts are used to tie the ribands to the angles. Timber wear treads are then nailed to the floor.

2. Layered flooring (fig. 165). Three- by twelve-inch planks are laid across the trusses between the angles. Every fifth timber is notched to fit over the horizontal legs of the angles. A second layer of 3-inch timbers is laid diagonally across the floor and nailed to the bottom layer. Wood ribands are used to hold the timber floor to the angles. Timber wear treads are then nailed to the floor.

(4) *Bearings.* (*a*) With end posts (①, fig. 166). End posts are normally used at both ends of each truss and seated on standard bearings. The top lugs of the end posts are cut off flush with the trusses so they do not interfere with the decking.

(*b*) *Without end posts* (②, fig. 166). If end posts are not used, the span is supported on timber blocking at the first panel junction from each end. The timber blocking must extend a minimum of 1 foot on each

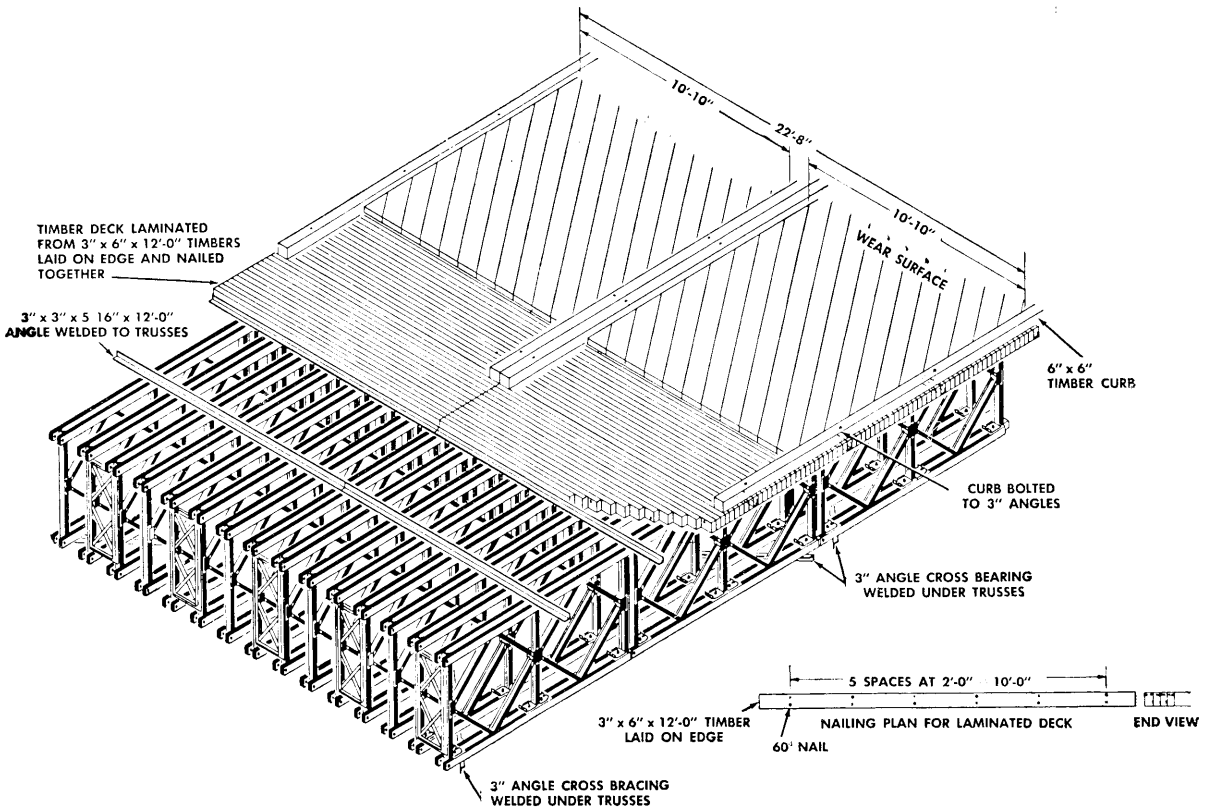


Figure 161. Details of laminated timber deck on a two-lane deck type panel bridge.

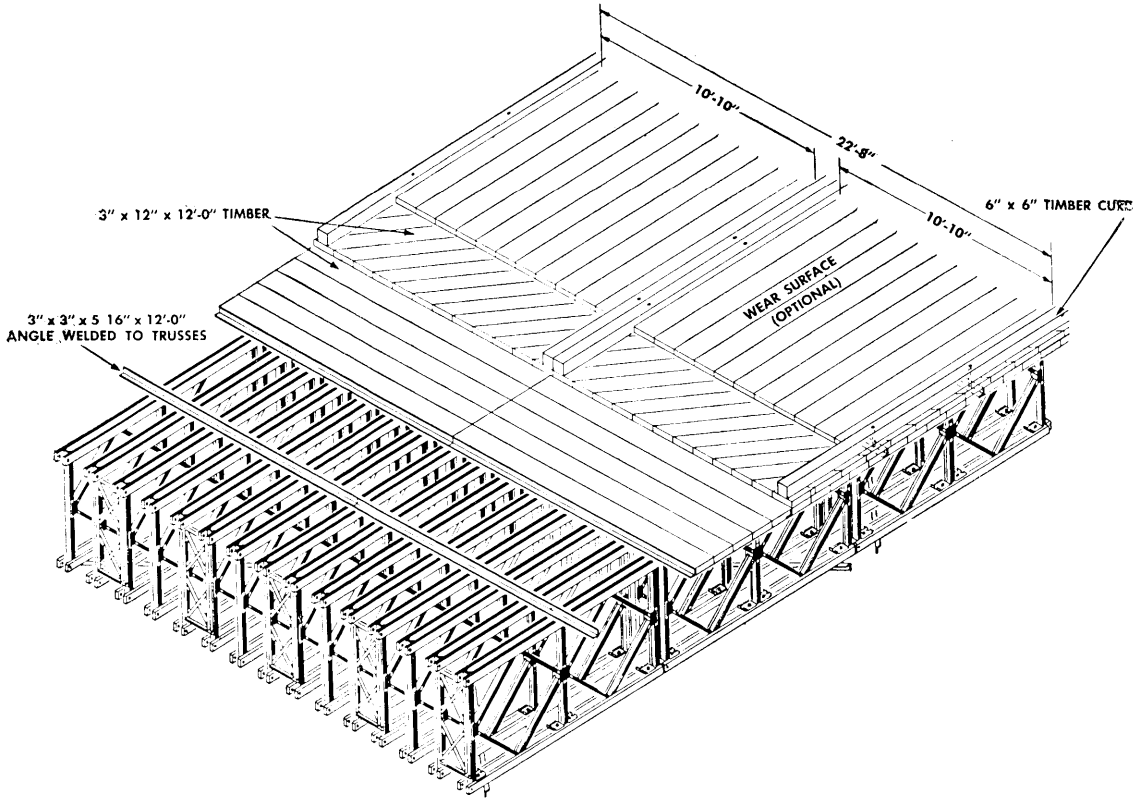
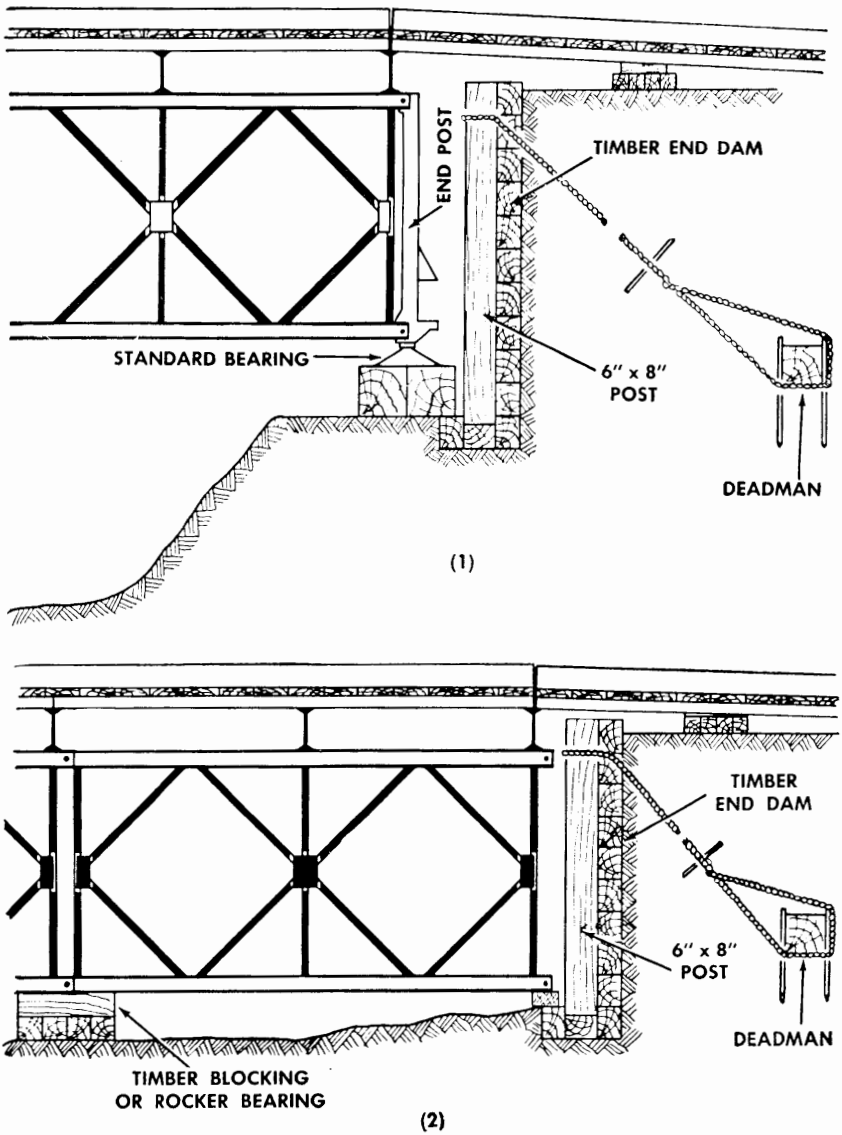


Figure 165. Details of layered timber deck on a two-lane deck type panel bridge.



① *With end posts.*

② *Without end posts. Last bay is cantilevered over the timber or rocker bearing.*

Figure 166. End bearings for deck type panel bridges.

side of the joint. An alternate method is to use a distributing beam on a rocker bearing similar to the support over intermediate piers. With this type of bearing, the effective bridge length is 20 feet greater than the gap between bearings. Timber blocking is also added under the cantilevered end of the panel to eliminate a reversal of stress in panels near end of bridge as a vehicle moves onto bridge.



Figure 167. Junction of two deck type spans on intermediate pier. Timber bent supports the decking between ends of spans.

(*c*) *Over intermediate piers.* The trusses can be continuous or broken over the intermediate piers. If they are continuous, a rocker bearing should be provided. (See ch. 24.) If broken, end posts are attached to the ends of the trusses and the two ends are seated on separate bearings. If timber flooring is used, the gap between the ends of the spans may require an intermediate trestle to support the decking (fig. 167). With panel bridge flooring, the gap between the ends of spans can be bridged by expedient timber or steel stringers and chess. (See ch. 24.)

b. Expedient Construction. For ease in launching, trusses may be grouped into two- or three-truss girders tied together by bracing frames. (These girders are spaced uniformly under the deck.) If other spacings of the trusses are used, expedient braces must be welded to the end verticals of the panels in place of bracing frames. Cross bracing must also be welded across the bottom chords. Examples of expedient construction are given in table 56.

190. Launching

a. Launching. Each three-truss girder may be launched separately or the entire bridge may be launched as a unit by welding additional bracing to tie the girders together.

(1) The individual girders of a single-story bridge are launched by pushing or pulling the girder and launching nose out over the gap, by launching from a high line, by launching with derrick and preventer tackle, or by lifting directly into place with one or two cranes. Over a

water gap, the girders may be placed on rafts and floated out into the gap and then lifted into place by a crane on a raft (fig. 168). For details of these launching methods, see chapter 29.

(2) A single-story bridge may also be launched as a unit by pushing or pulling it on rollers out over the gap (fig. 169).

(3) Double-story bridges are launched as a unit. Transverse channels welded across the tops of the bottom and intermediate chords tie the girders together. The entire unit may be launched with a launching nose and then jacked down onto the bearings. If a temporary pier can be built in the middle of the gap to support the cantilevered end, the bridge can be launched as a single-story unit, the lower story being added from an erection platform just below the near bank seat. This method reduces the jacking height. It is similar to the method used for launching triple-story bridges with underslung bottom story described in chapter 13.

b. Lowering to Bearings. A crane at each end of the bridge can be used to lower the girders to the bearings. Jacks can be used as an expedient, although the 5-foot drop requires several lifts. During jacking, blocking must be used under the trusses to take the load in case the jacks fail.

191. Expedient Design Bridges

Table 56 lists several typical deck type panel bridges built in the European Theater of Operations (ETO).

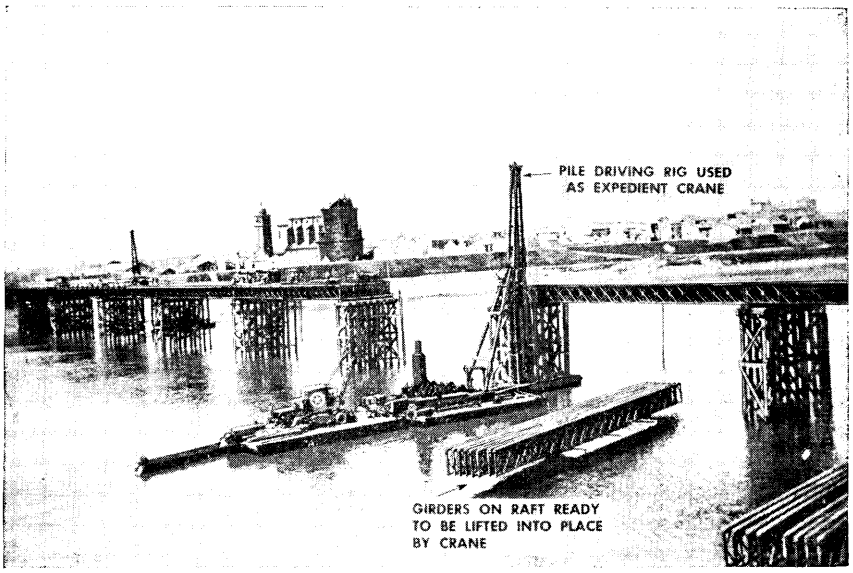
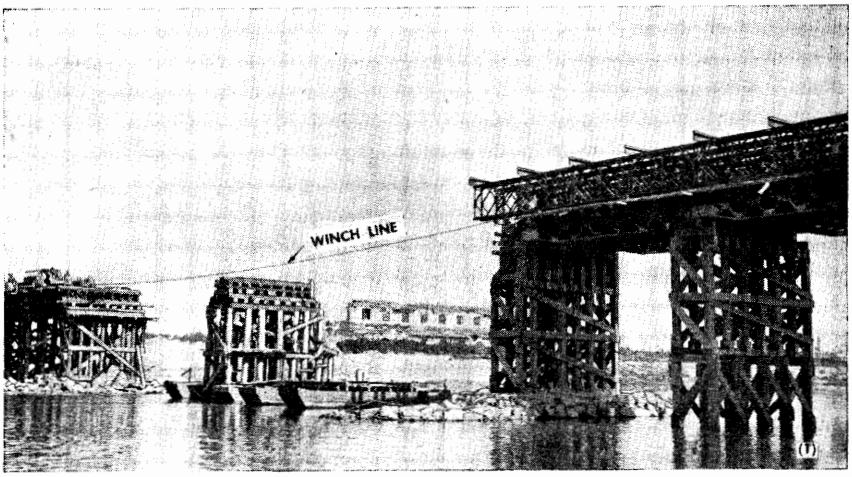


Figure 168. General view of construction of two-lane deck type panel bridge. Note girders on rafts preparatory to being lifted into place by pile driving rig used as expedient crane.

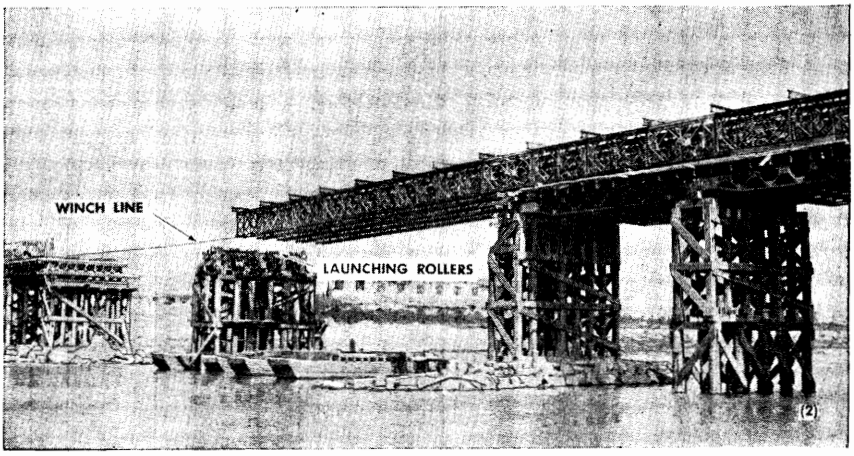
Table 56. Typical Highway Deck Type Panel Bridges Built in ETO

Location	Tiber River, Borghetto, Italy.	Autobahn Highway, Bayreuth, Germany.	Arno River, Pisa, Italy.	Po River, Ostiglia, Italy.
Span	Continuous over four spans at 80, 90, 90, and 80 feet.	Continuous over two 55-foot spans.	Continuous over two 85-foot spans.	Continuous over thirteen 100-foot spans.
Capacity*				
One way	Class 80	Class 80	Unknown	Class 100.
Two way	Class 45	Class 45		Class 55.
Road width (feet)	24	25	20	About 22.
Truss construction	18 trusses tied together by vertical bracing frames and tie plates into 2 five-truss and 2 four-truss girders.	8 trusses tied together by vertical bracing frames into 4 two-truss girders.	10 trusses tied together by vertical bracing frames into 5 two-truss girders.	16 trusses tied together by vertical bracing frames into 8 two-truss girders.
Special bracing	3"x3" angle cross bracing welded under bottom chords.	6" channels transverse to center line of bridge welded to top and bottom chords at 20' spacings.	10" steel I-beam floor beams welded across top chords at 2'-6" spacings.	Angle cross bracing welded under bottom chords.
Deck	3 layers of 2" timber nailed to nailing strips bolted to trusses. Bottom 2 layers laid diagonally, top layer laid transversely, and surfaced with bituminous surfacing.	9" timber flooring nailed to nailing strips bolted to trusses.	2 layers of 3" timber nailed to nailing strips bolted to floor beams.	2 layers of timber nailed to nailing strips bolted to trusses. Bottom layer laid transversely, top layer laid diagonally.
Launching	Each girder launched separately. Girder and launching nose pulled on rollers cut over gap.	Each girder launched separately on rollers.	Entire unit launched on rollers without a launching nose.	Each girder lifted directly into place by pile driving rig.
Figure reference	Figure 170	Figure 171	Figures 161, 169 and 172.	Figures 160, 167 and 168.

* Capacities are those assigned to bridge in the field. Actual capacity may be greater.



(1) *Bridge before launching.*



(2) *Bridge during launching.*

Figure 169. Launching Pisa bridge. Five two-truss girders are tied together by I-beams welded across top chords. Winch line from truck on far shore is used to pull bridge across gap.

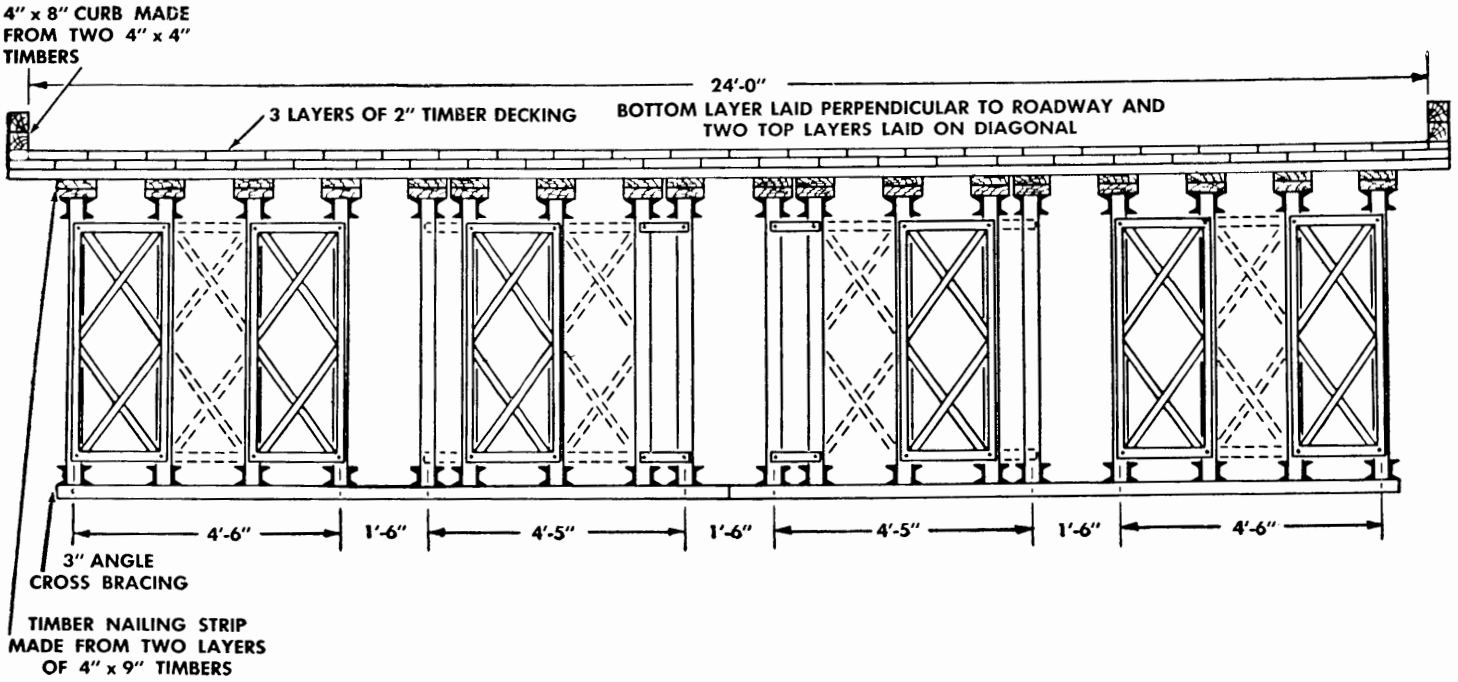


Figure 170. End view of truss construction in Borghetto bridge.

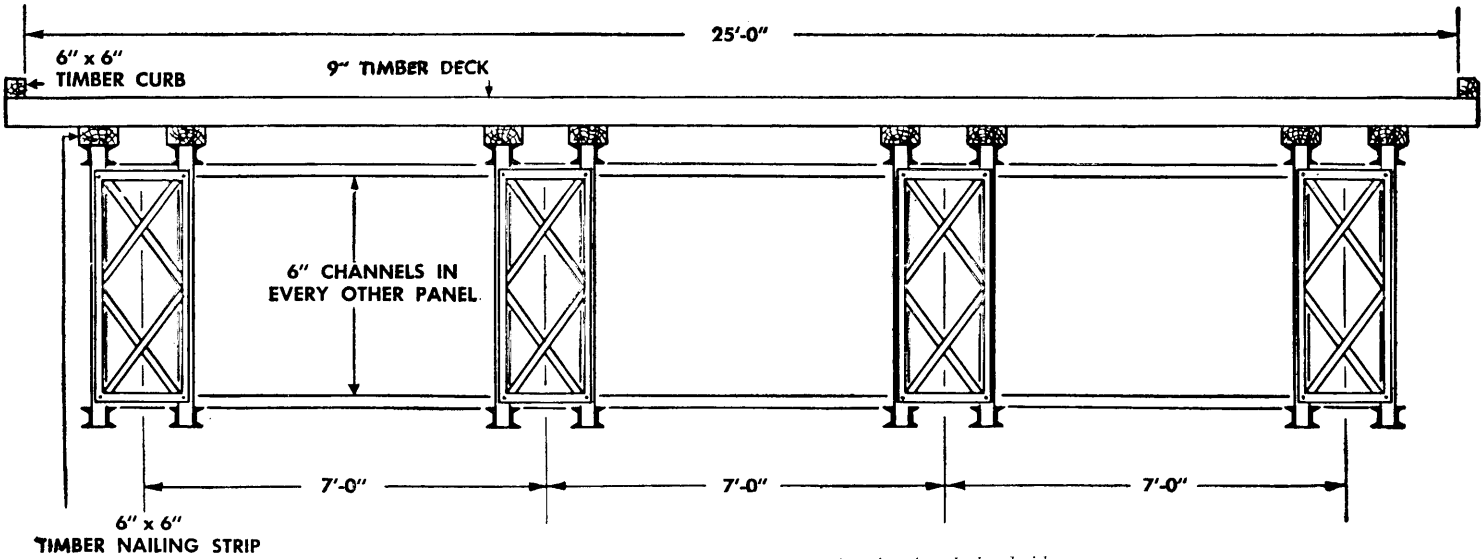


Figure 171. End view of truss construction in Autobahn bridge.

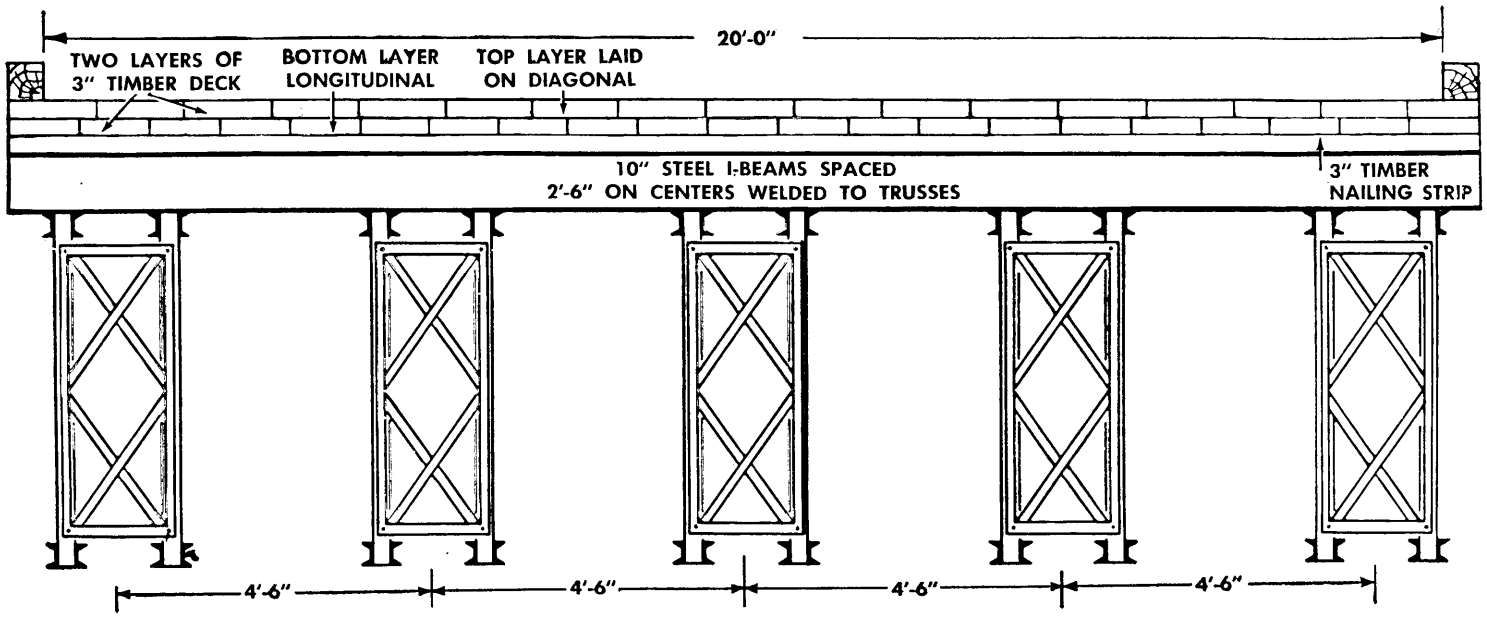


Figure 172. End view of truss construction in Arno River bridge.

CHAPTER 22

RAILWAY BRIDGES

192. Scope

This chapter describes the use of panel bridge equipment to build fixed railway bridges.

193. Use

Panel bridge equipment can be used as an expedient for the construction of railway bridges. Usually, panel bridge railway bridges are constructed as single-track bridges (fig. 173).

a. ADVANTAGES. Panel bridge equipment has the following advantages for use as railway bridging:

(1) The equipment can be transported in 2½-ton trucks to bridge site. This permits bridge construction at the same time repairs are being made on the approach tracks.

(2) Either through or deck type bridges can be built.

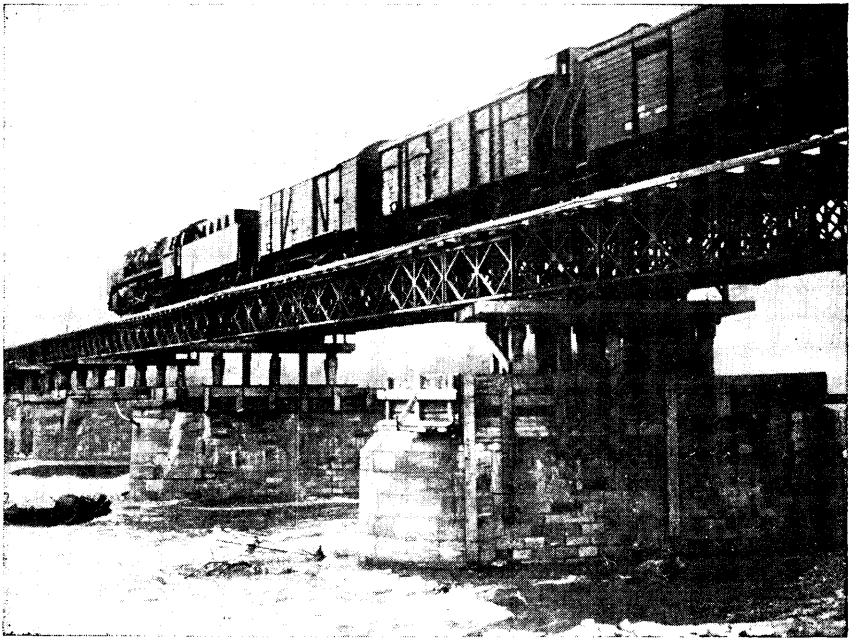


Figure 173. Single-track deck type railway bridge over the Moselle River, near Charmes, France.

b. DISADVANTAGES. Panel bridge equipment has the following disadvantages for use as railway bridging:

(1) Through type bridge provides restricted clearance.

(2) Traffic over bridge must be controlled to eliminate excessive vibration and side sway.

(3) Pin clearance allows more sag than is found in a normal bridge.

(4) Bridge requires more maintenance than standard bridges.

194. General Description

The bridge can be either through type or deck type construction.

a. THROUGH TYPE BRIDGE. The through type railway bridge is built the same as the normal panel bridge with ties and rails in place of chess. Girders can be single-, double-, triple-, and quadruple-truss and single-, or double-story. The trusses of double-story bridges infringe US main line and Berne international clearance gages but allow passage at slow speeds (fig. 174). If flooring of double-story trusses is placed in the top story, the trusses do not infringe standard clearance gages.

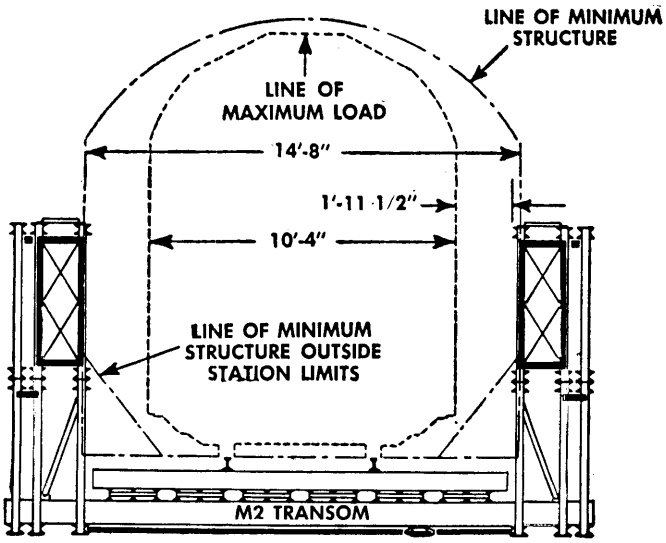
b. DECK TYPE BRIDGE. In the deck type bridge, the trusses are spaced under the ties. The trusses are usually single-story. They are tied together laterally by bracing frames, tie plates, expedient angle cross bracing, and the ties.

195. Capacity

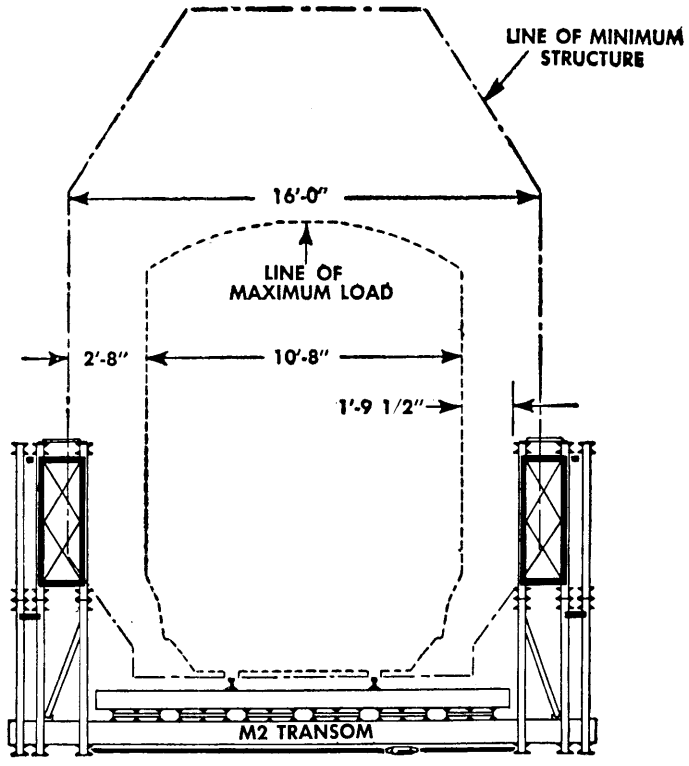
The standard designs described will carry standard or modified Cooper's E–40 loading (see fig. 175 for diagrams of loadings). Table 57 gives the shears and moments caused by these loadings. Table 58 gives the construction required for 10- to 100-foot spans using three standard designs.

196. Details of Construction

a. THROUGH TYPE BRIDGE. (1) *Trusses.* Single-, double, and triple-truss construction can be used as in normal panel bridge construction. A quadruple truss can be constructed by inserting a fourth truss between the inner and second truss of a triple truss. Bracing frames and tie plates are used to tie the four trusses together (fig. 176). Transom clamps are used on all panel verticals except the three verticals in each bay covered by bracing frames. Transoms are modified by cutting a hole in the flange and web at each end to seat the pintle of the fourth truss. Since the fourth truss interferes with the use of rakers, double-story quadruple-truss bridges are usually constructed with the floor in the top story.



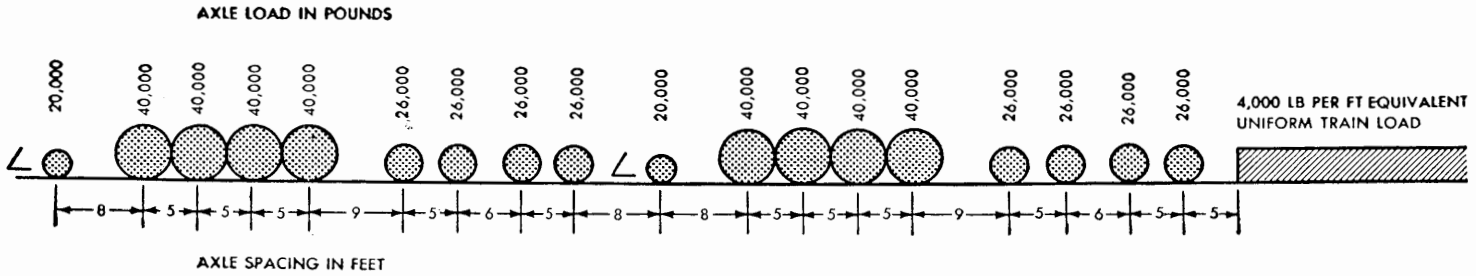
(1)



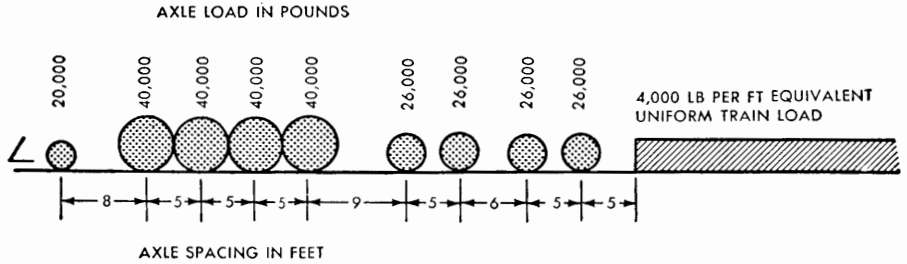
(2)

① *Berne international clearance diagram for M2 bridges.*
② *US unrestricted main line clearance diagram for M2 bridge.*

Figure 174. Railway clearance diagrams for M2 through-type panel bridges.



STANDARD COOPER'S E-40 RAILWAY LOADING
(TWO LOCOMOTIVES)



MODIFIED COOPER'S E-40 RAILWAY LOADING
(SINGLE LOCOMOTIVE)

Figure 175. Diagram of standard and modified Cooper's E-40 loadings.

*Table 57. Maximum live-load moments and live-load shears Caused by Cooper's E–40 Loadings**

Span (ft)	Standard Cooper's E–40 loading (two locomotives)		Modified Cooper's E–40 loading (single locomotive)	
	Maximum shear (tons)	Maximum moment (ft-tons)	Maximum shear (tons)	Maximum moment (ft-tons)
10	30	56	30	56
20	50	206	50	206
30	63	411	63	411
40	75	656	75	656
50	87	951	87	951
60	98	1300	98	1285
70	110	1707	108	1640
80	124	2160	119	2047
90	137	2670	129	2481
100	150	3220	140	2944

* See figure 175 for diagram of standard and modified Cooper's E–40 loadings.

Table 58. Number of trusses required for various spans of Bailey Type Panel Railway Bridge[1]

Span (ft)	Standard Cooper's E–40 loading			Modified Cooper's E–40 loading		
	Through type bridge[2]	Deck type bridge[3]		Through type bridge[2]	Deck type bridge[3]	
		Type I bridge	Type II bridge		Type I bridge	Type II bridge
10	SS	.....	.....	SS	.....	.....
20	DS	.....	.....	DS	.....	.....
30	TS	5	.....	TS	5	.....
40	TS	6	6	TS	6	6
50	QS or DD	7	7	QS or DD	7	7
60	QS or TD	8	8	QS or TD	8	8
70	TD	9	9	TD	9	9
80	QD	10	10	TD	9	10
90	QD	11	12	QD	11	12
100	.....	.....	16	QD	.....	16

[1] Including an allowance of 25 percent of live load for impact.
[2] Based on the following allowable loads:

Table 58. Number of trusses required for various spans of Bailey Type Panel Railway Bridge[1]—Continued

Construction	SS	DS	TS	QS	DD	TD	QD	DT	TT
Allowable shear (tons).	40	80	110	140	135	175	215	135	175
Allowable moment (ft-tons)	760	1520	2080	2640	2800	3760	4720	5240	7024

[1] Based on allowable shear in each truss of 20 tons, allowable moment in each truss of 380 foot-tons, and 90 percent truss efficiency.

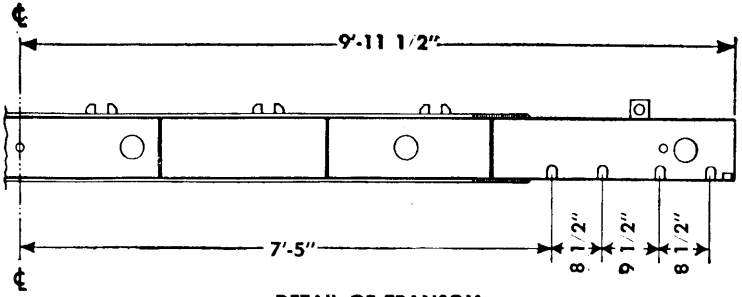
(2) Floor system. For railway loads, double transoms are always used. Stringers are placed as in a normal panel bridge. If 8- by 10-inch by 14-foot ties are used, they are placed directly on the stringers at 20-inch spacings and hook-bolted to button stringers (see fig 177 ①). To use standard ties (6 by 8 inches by 8 feet 6 inches), chess and ribands are laid in the normal manner and the ties are spiked to the chess (see fig. 177 ②). By building up timber treads on each side and between the rails, the bridge can be used for rail or highway traffic (fig. 177 ③). Rail joints on bridge should be tight (no allowance for expansion) to reduce impact.

(3) *End Bearings.* End posts and bearings are used as in a normal panel bridge. Grillage must be enough to carry the loads given in table 59. Ramp sections must be level with the bridge floor.

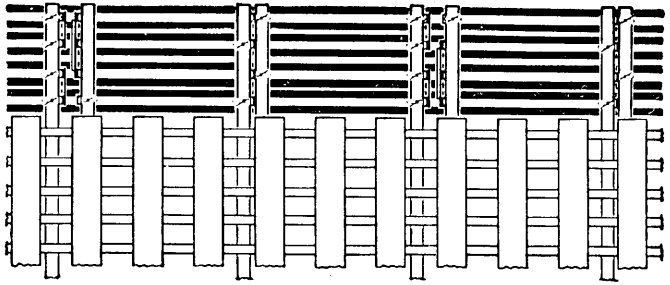
Table 59. Abutment reaction in tons for various spans of Bailey type Panel Railway Bridge Under Cooper's E–40 Loading

Span (ft)	Standard Cooper's E–40 loading			Modified Cooper's E–40 loading		
	Through type bridge*	Deck type bridge		Through type bridge*	Deck type bridge	
		Type I bridge	Type II bridge		Type I bridge	Type II bridge
10	40	.....	.....	40	.....	.....
20	67	.....	.....	67	.....	.....
30	87	83	.....	87	83	.....
40	104	100	101	104	100	101
50	124	117	118	124	117	118
60	143	132	134	143	132	134
70	163	151	154	160	148	151
80	188	171	173	177	164	167
90	208	191	195	198	181	185
100	.....	.....	221	217	.....	208

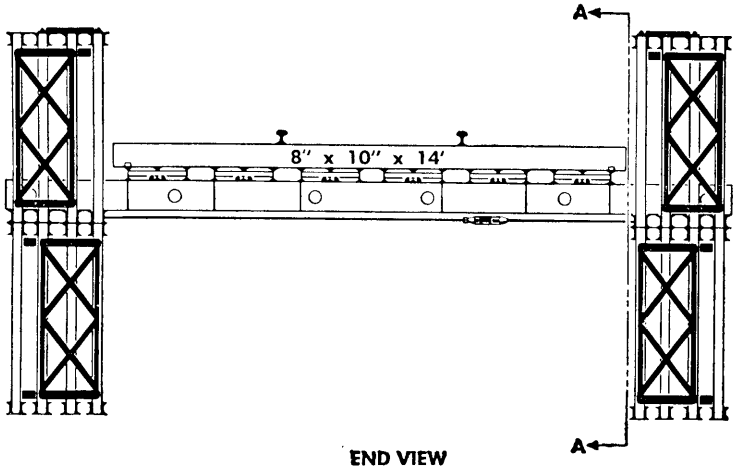
* Sum of reactions on both base plates.



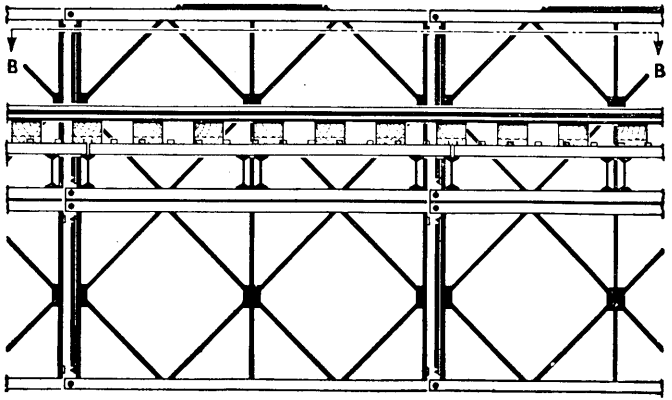
DETAIL OF TRANSOM



SECTION B-B

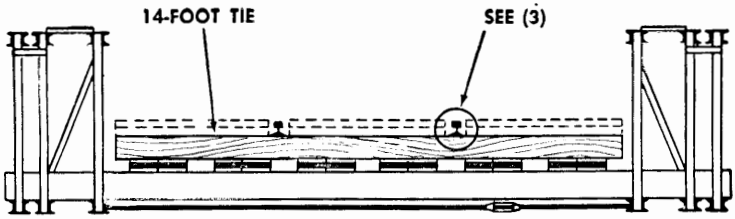


END VIEW



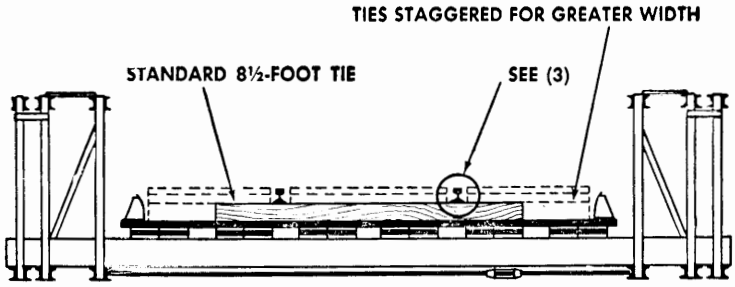
SECTION A-A

Figure 176. Quadruple-truss double-story through type panel railway bridge.



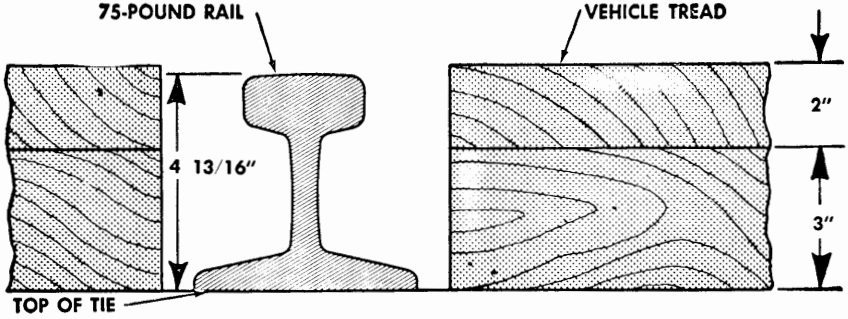
USING 14-FOOT TIES

(1)



USING STANDARD 8½-FOOT TIES

(2)



DETAIL OF VEHICLE TREAD FOR COMBINATION HIGHWAY-RAILWAY BRIDGE

(3)

① *Using 14-foot ties.*
② *Using standard 8½-foot ties.*
③ *Detail of vehicle tread for combination highway-railway bridge.*

Figure 177. Decking of through type panel railway bridge.

b. DECK TYPE BRIDGE. Two deck type designs are described here. Type I is used for spans up to 90 feet, type II spans gaps up to 100 feet.

(1) *Type I.* (*a*) *Trusses.* Trusses are arranged side by side and connected by bracing frames and tie plates as shown in figure 178. Bracing is supplied by the ties, welded sway bracing, and modified transoms. The modified transoms are seated adjacent to the center vertical in the top and bottom chord of every second and third bay. To seat the upper transom, every other truss is inverted. The modified transoms are cut to the desired length and holed to seat the pintles on the panels. Three-inch angle sway bracing is welded diagonally under the bottom chords of every two bays.

(*b*) *Floor system.* Four 6- by 12-inch ties are used in each bay. Every other tie is chord bolted to the trusses. Holes for the chord bolts are drilled as shown in figure 179. A 6- by 6-inch curb is spiked to the ties.

(*c*) *End bearings.* End posts are used at each end of each truss and are seated on standard bearings. Grillage under the bearings at each abutment must be sufficient to support loads given in table 59. Rocker bearings over intermediate piers can be made similar to those described in chapter 24.

(2) *Type II.* (*a*) *Trusses.* Trusses are braced by bracing frames and tie plates into 2- , 3- , or 4-truss girders suitable for launching separately. The girders are grouped together to form 6-, 7-, 8-, 9-, 10, -12, and 16-truss bridges as illustrated in figure 180. The 2-truss girder is made from 2 trusses braced at the end verticals by bracing frames. A 3-foot wide 3-truss girder is made from 3 trusses braced by bracing frames. A 1½-foot 3-truss girder is made by adding a third truss between the trusses of the 2-truss girder and bracing it with tie plates to one of the outer trusses. A 4-truss girder is made by adding another truss 8½ inches outside a 1½-foot 3-truss girder and bracing it with tie plates. The girders are tied together in the bridge by the ties and two modified transoms on the bottom chord of each bay. Transoms are modified by cutting holes in the flange to seat the pintles on the panels. Raker lugs are welded to the transom so rakers can be used between the transom and the outside trusses.

(*b*) *Floor system.* The same type floor system is used as in the type I bridge.

(*c*) *End bearings.* The same type of bearings are used as in the type I bridge.

197. Launching

a. THROUGH TYPE BRIDGE. Through type bridges are launched on rollers in the same manner as a normal panel bridge.

b. DECK TYPE BRIDGE. (1) *Type I bridge.* These bridges are designed to be launched complete on rollers. They can be pushed or pulled across

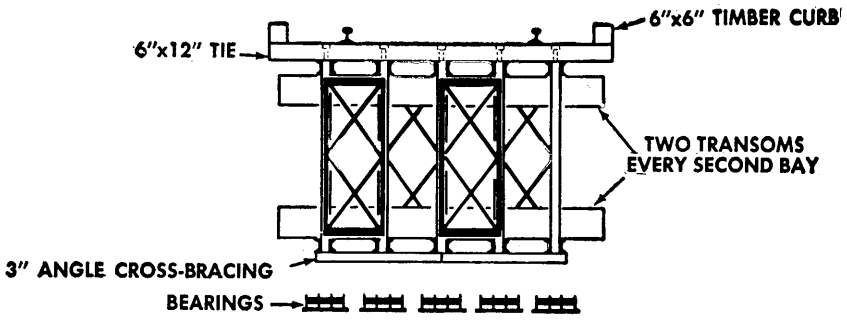
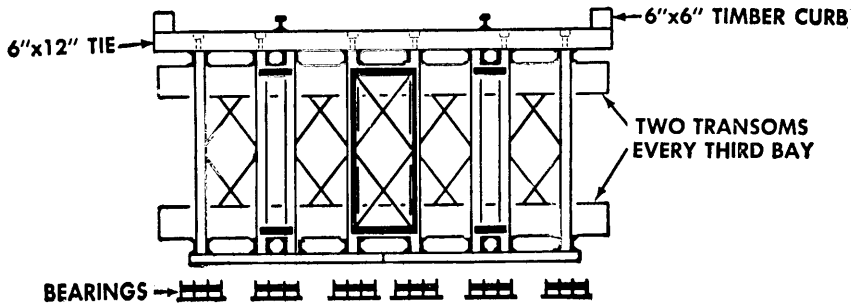
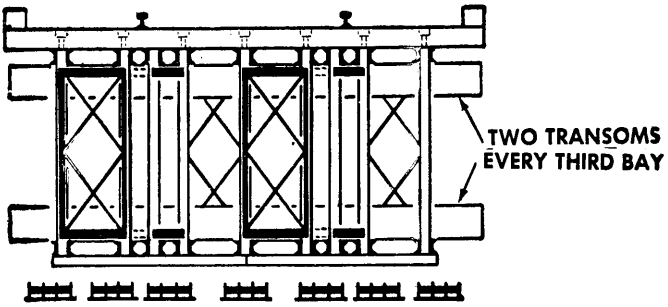


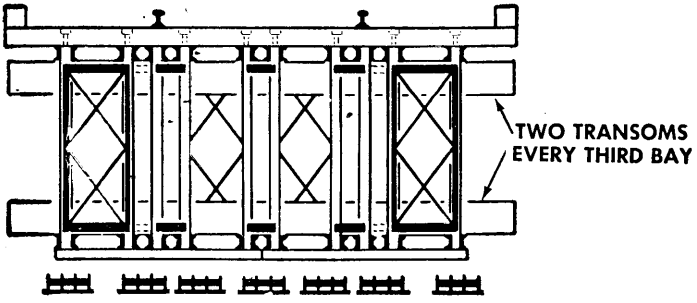
Figure 178. Construction of type I deck railway bridges.



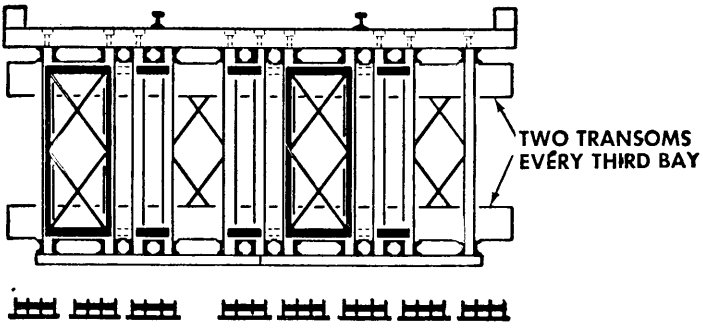
(4) EIGHT-TRUSS BRIDGE



(5) NINE-TRUSS BRIDGE

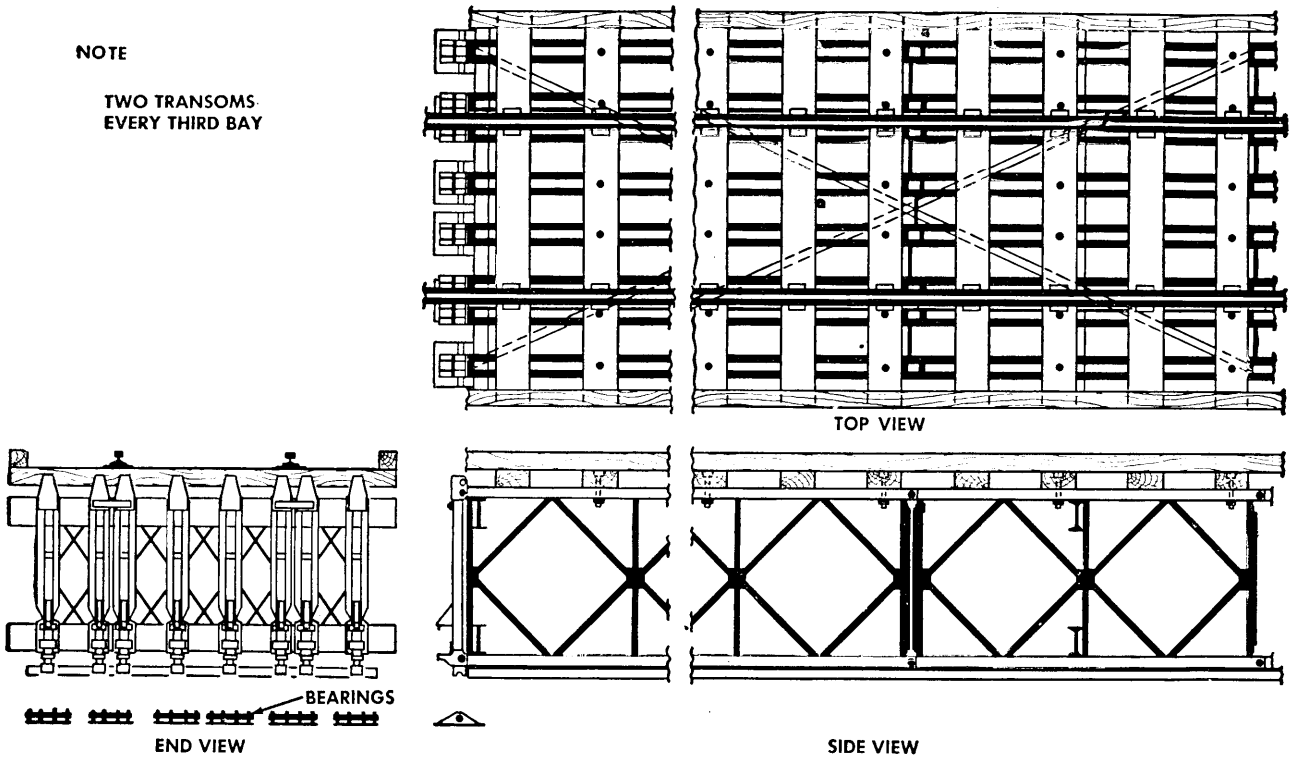


(6) TEN-TRUSS BRIDGE



(7) ELEVEN-TRUSS BRIDGE

Figure 178. Construction of type I deck railway bridges—Continued.



(8) TOP, SIDE, AND END VIEW OF EIGHT-TRUSS BRIDGE SHOWING CONSTRUCTION DETAILS

Figure 178. Construction of type I deck railway bridges—Continued.

by a winch line. Launching noses can be used as illustrated in figures 181 and 182. During launching, extra bracing frames and tie plates are used on the top chords.

(2) *Type II bridge.* Each girder of the bridge is launched separately by cantilevering out on rollers. Flooring and bracing between girders are added after girders are in place. For other methods of launching single girders, see chapter 29.

198. Expedients

Table 60 lists panel railway bridges built in the European Theater of Operations.

a. BRACING. Welded vertical cross bracing at each panel junction can be used instead of bracing frames and tie plates. Four-inch channels welded across the panel chords can be used in place of transoms.

b. BEARINGS. If end posts are not used, the abutment bearings can be made from a rigid distributing beam on timber grillage (fig. 193). The beam must support at least two panel support points.

c. LAUNCHING. Each truss or two-truss girder can be launched from a high-line or lifted directly into place by a crane.

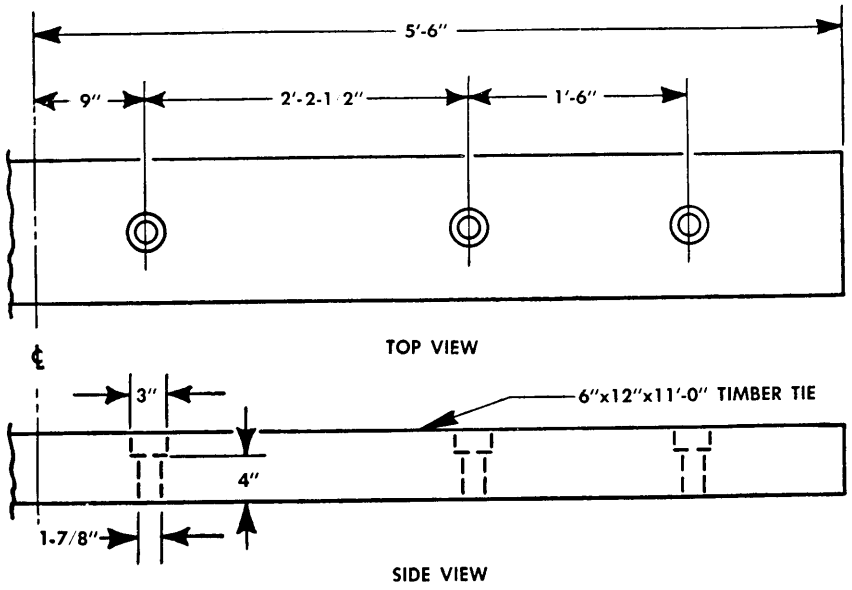


Figure 179. Details of railway tie for eight-truss bridge showing chord bolt holes.

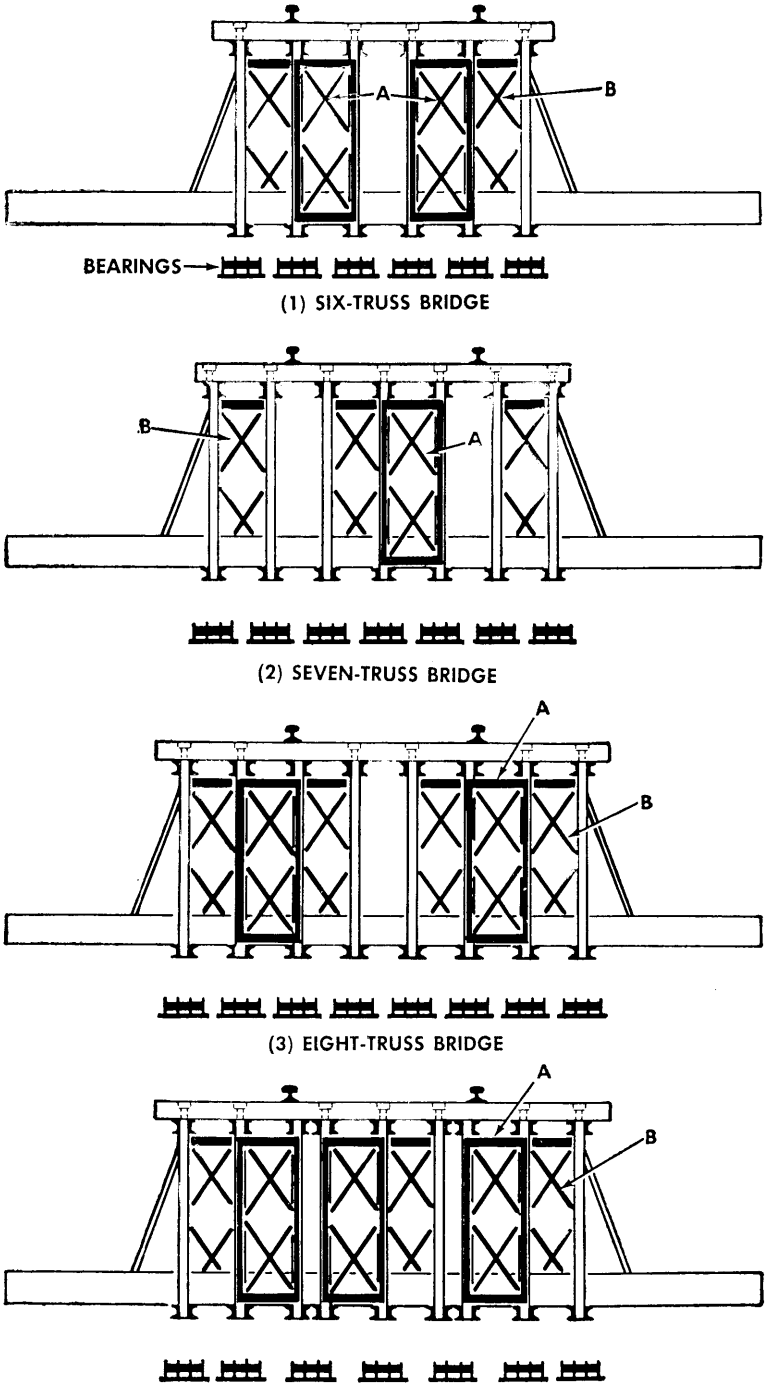
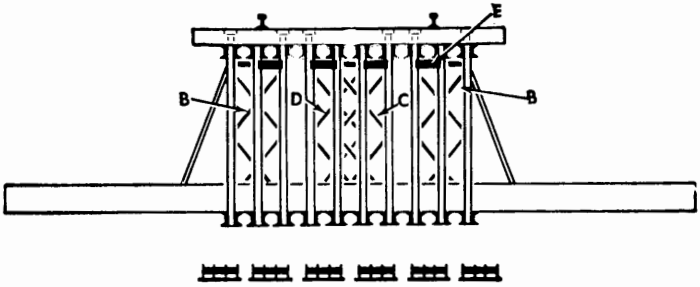
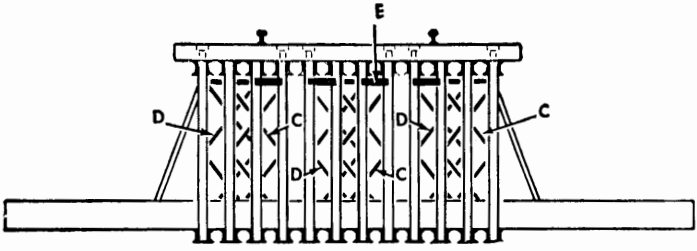


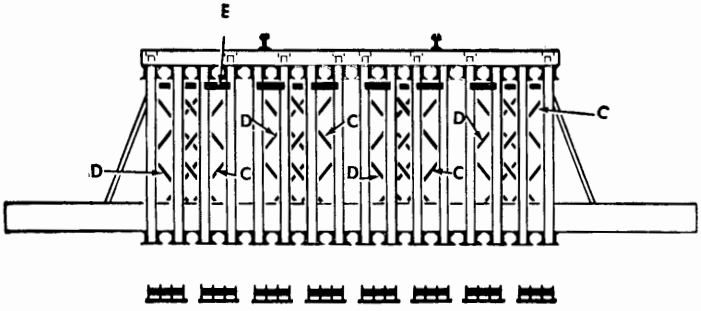
Figure 180. Construction of type II deck railway bridges.



(5) TEN-TRUSS BRIDGE



(6) TWELVE-TRUSS BRIDGE



(7) SIXTEEN-TRUSS BRIDGE

LEGEND

BRACING FRAMES

A—ON FRONT END OF PANELS IN EVERY BAY

B—ON BACK END OF PANELS IN EVERY BAY

C—ON BACK END OF PANELS IN ODD NUMBERED BAYS

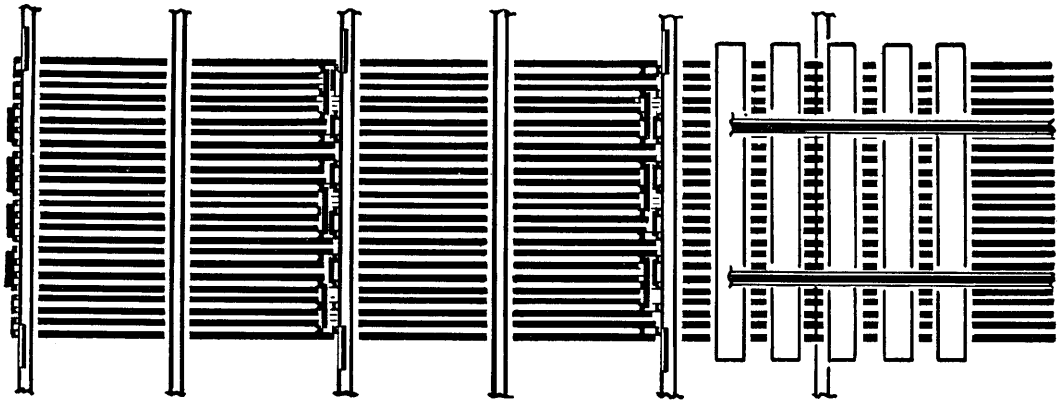
D—ON BACK END OF PANELS IN EVEN NUMBERED BAYS

TIE PLATES

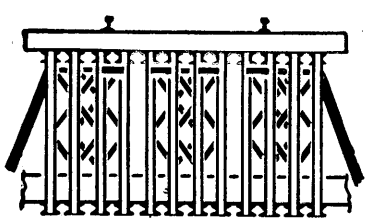
E—ON FRONT END OF PANELS IN EVERY BAY

Figure 180. Construction of type II deck railway bridges—Continued.

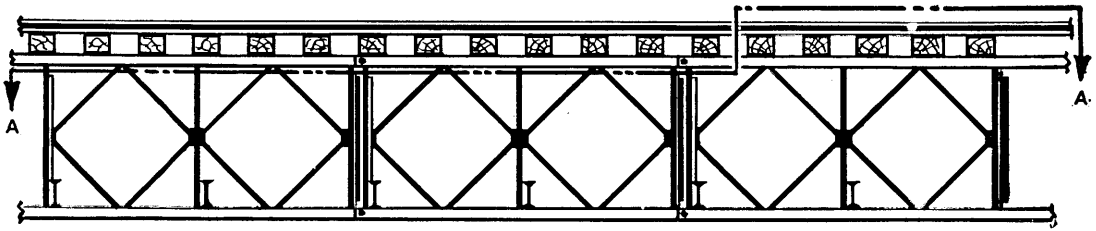
NOTE
NEW RAKER LUGS WELDED TO TRANSOMS AT REQUIRED SPACING



SECTION A-A



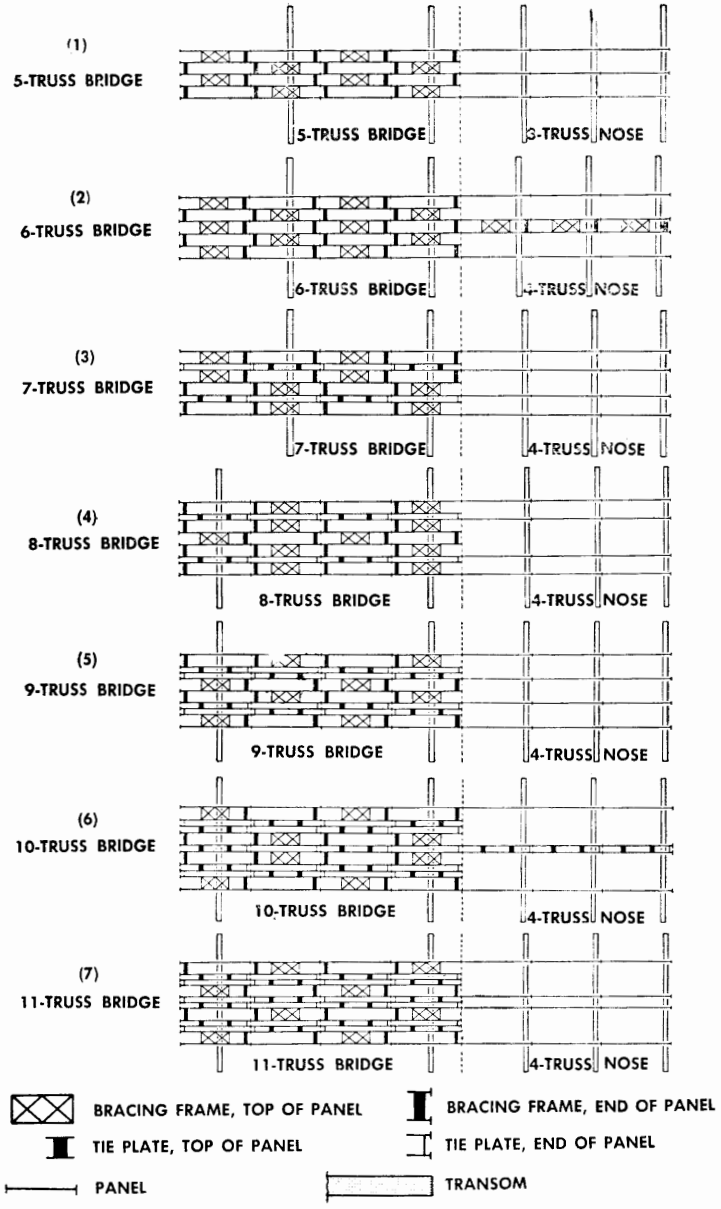
END VIEW



SIDE VIEW

(8) TOP, SIDE, AND END VIEW OF TWELVE-TRUSS BRIDGE SHOWING CONSTRUCTION DETAILS

Figure 180. Construction of type II deck railway bridges—Continued.



① *Three-truss nose for 5-truss bridge.*
② *Four-truss nose for 6-truss bridge.*
③ *Four-truss nose for 7-truss bridge.*
④ *Four-truss nose for 8-truss bridge.*
⑤ *Four-truss nose for 9-truss bridge.*
⑥ *Four-truss nose for 10-truss bridge.*
⑦ *Four-truss nose for 11-truss bridge.*

Figure 181. Construction of launching noses for type I deck railway bridges.



Figure 182. Launching Pont d'Ain bridge over Ain River near Poncin, France. Winch line was used to pull 170-foot nine-truss bridge and 50-foot four-truss launching nose across the gap.

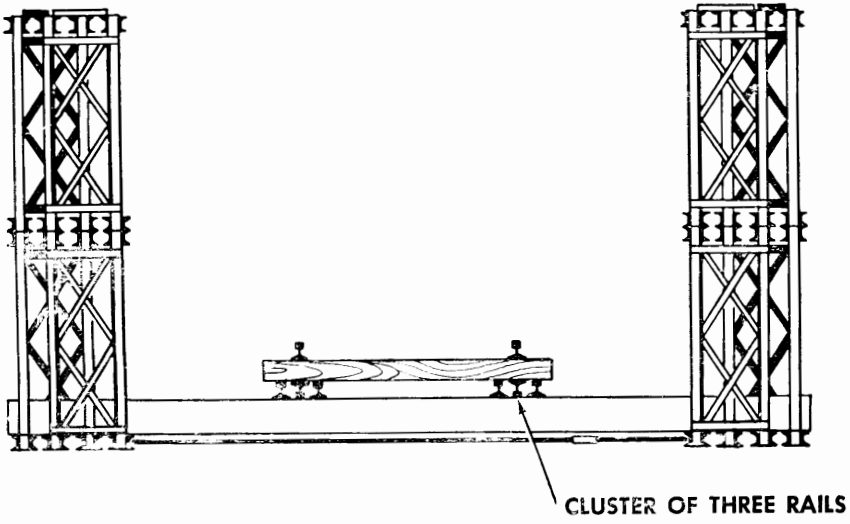


Figure 183. End view of 90-foot QD railway bridge built at Kings Newton bridging school to carry the equivalent of Cooper's E–35 loading.

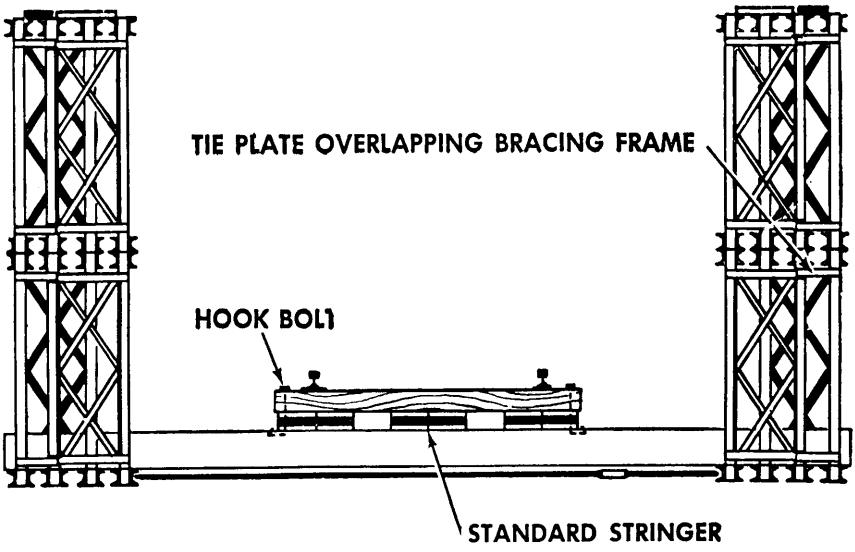


Figure 184. End view of 80-foot QD railway bridge built at Rakha Mines, India to carry the equivalent of Cooper's E–35 loading.

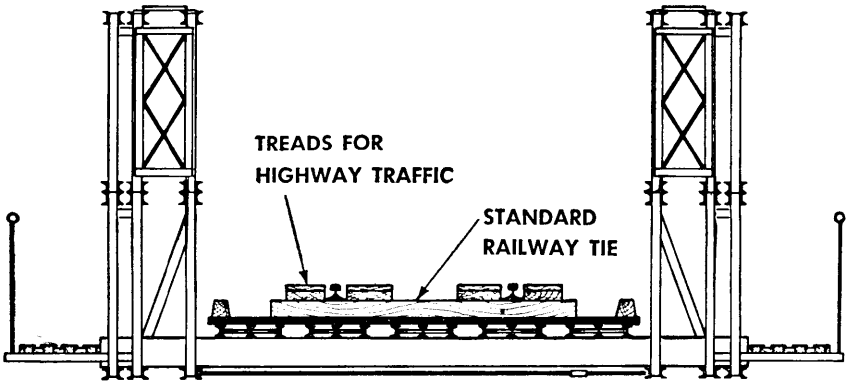


Figure 185. End view of TD combination highway-railway bridge built in Sicily.

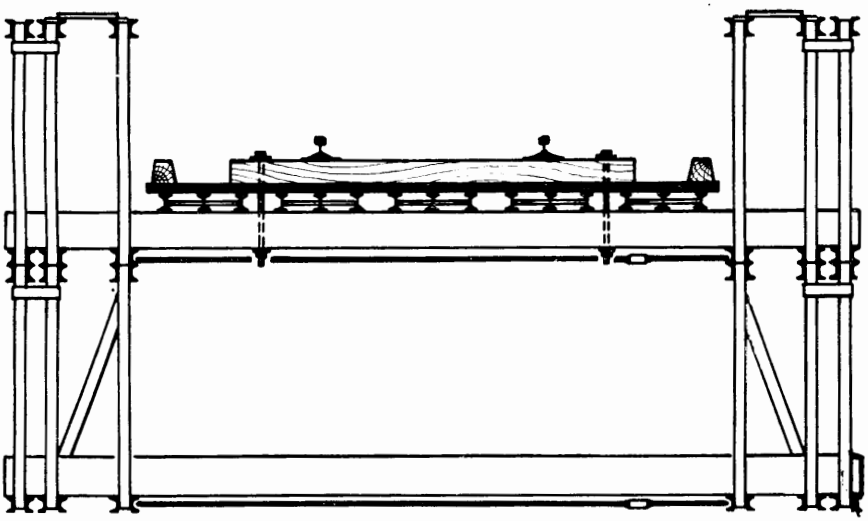


Figure 186. End view of TD class 70 railway bridges built over the Ofanto and Cevaro Rivers, Italy.

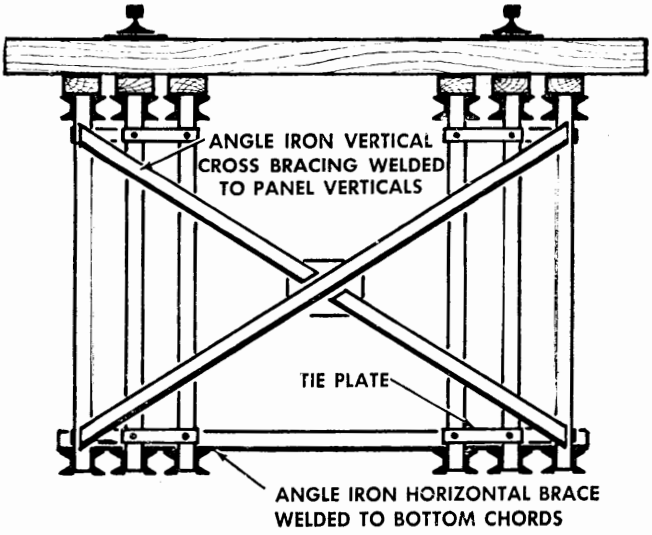


Figure 187. End view of six-truss deck railway bridge built over the Durance River south of Sisteron, France.

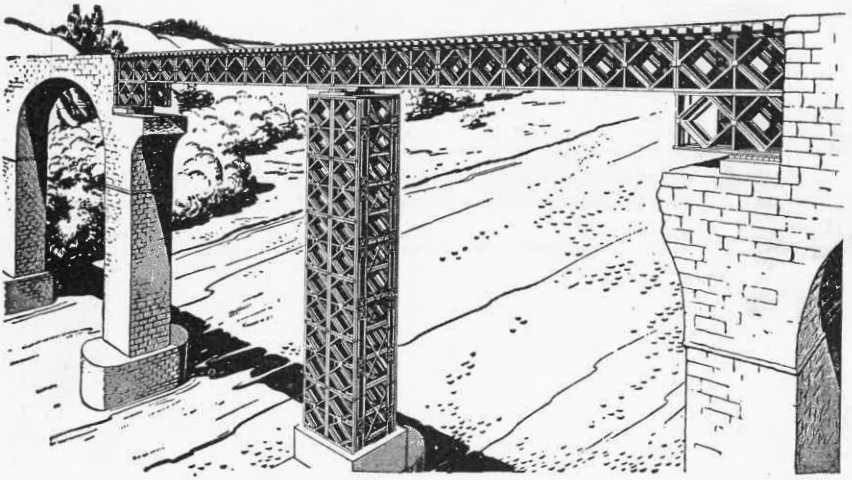


Figure 188. View of six-truss deck railway bridge built over the Durance River at Sisteron, France.

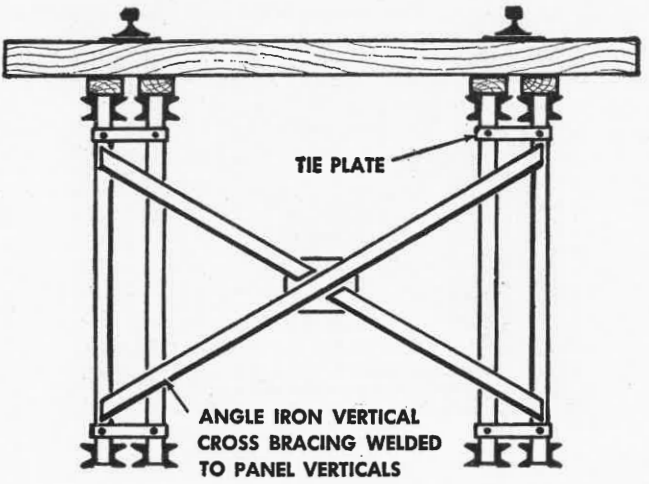


Figure 189. End view of the Montrond bridge, a four-truss deck railway bridge built over the Buech River at Serres, France.

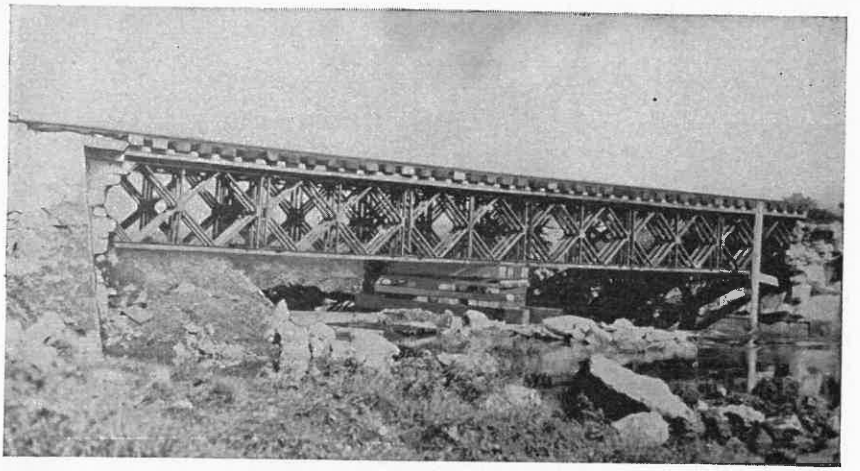


Figure 190. View of six-truss deck railway bridge built at Arbois, France.

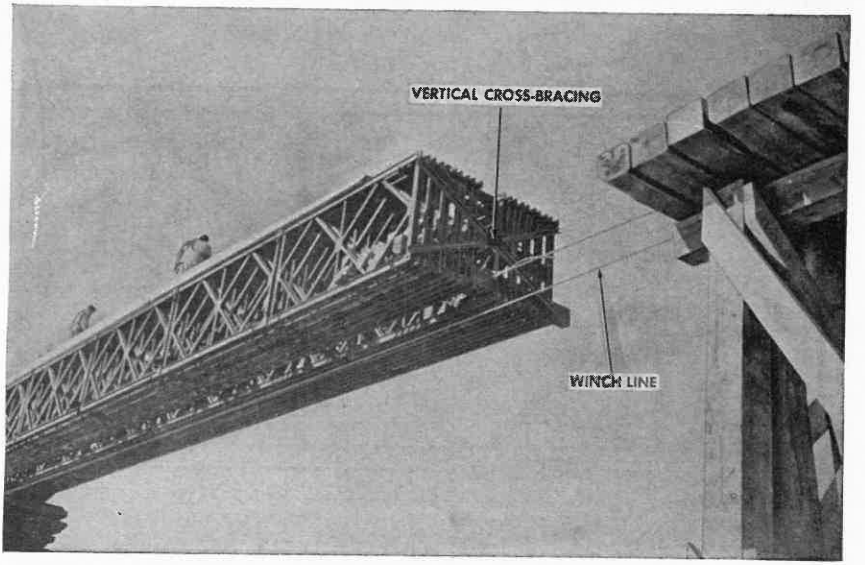


Figure 191. Launching ten-truss deck railway bridge over the Doubs River at Dole, France. Bridge was pulled across gap by a winch line.

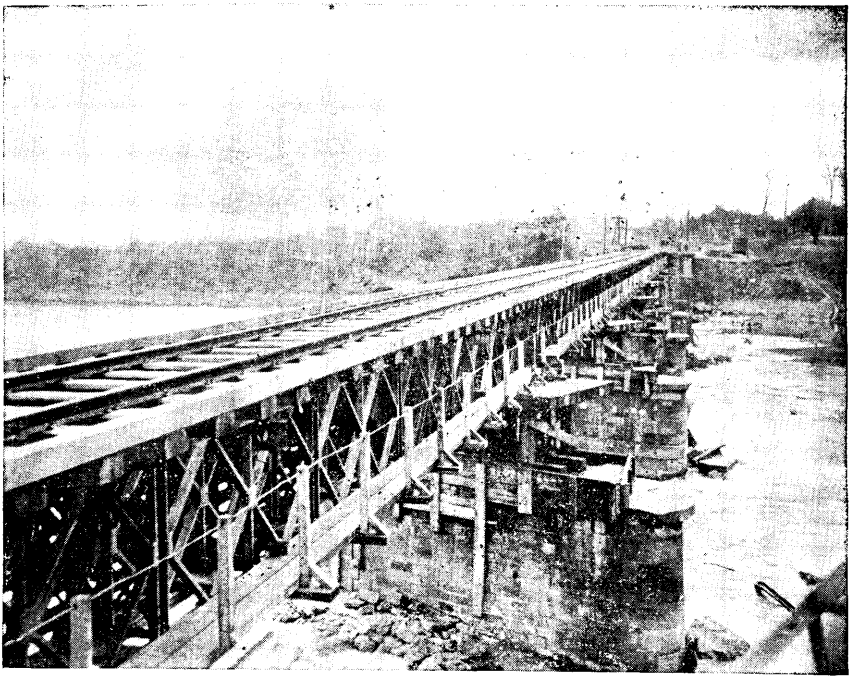


Figure 192. View of Langley bridge, on eight-truss deck railway bridge built over the Moselle River near Charmes, France.

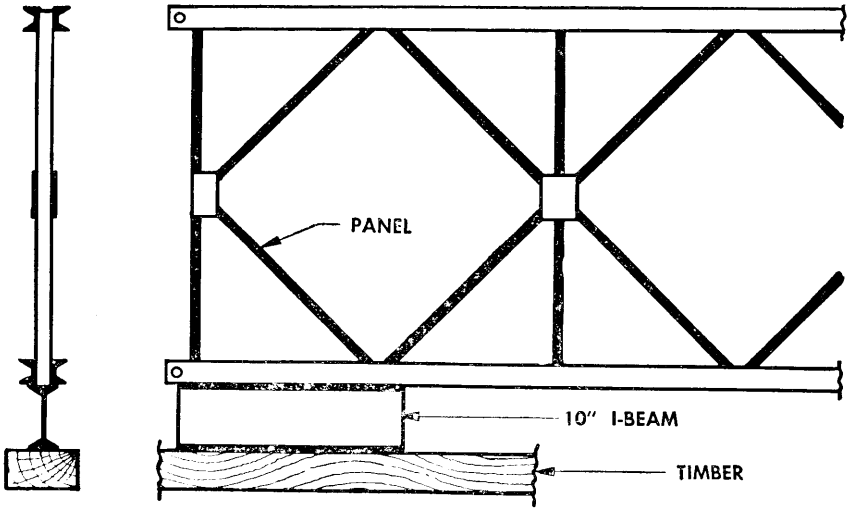


Figure 193. Expedient end bearings for deck panel bridge. Rigid distributing beam must support at least two panel-support points.

CHAPTER 23
REINFORCED BRIDGES

199. Scope

This chapter describes partial reinforcement of fixed panel bridges with standard and special parts to increase load capacity with minimum labor and material. Reinforcement of fixed panel bridges by converting completely to another type of construction is given in chapters 11, 12, and 13.

200. General

a. DESIGN. The critical design factor in most fixed panel bridges is bending moment. This factor varies from a maximum at the center of the span to zero at the supports. Unit construction of the panel bridge, however, produces girders of uniform section and strength throughout their entire length. Only center bays of most spans are therefore fully stressed. The greater part of the capacity of end bays is not utilized. By reinforcing only the center bays where bending-moment load is greatest a more uniform distribution of stress is obtained. Reinforced bridges carry more load for bridge parts used in their construction than do standard bridges.

b. LIMITATIONS. Short spans of SS, DS, DT, and TT are limited in capacity by shear in end bays. They cannot be strengthened by local reinforcement of center bays as described in *a* above and are not included in capacity tables 61 and 62.

201. Reinforcement with Partial Story

a. DESCRIPTION. DS, TS, DD, and TD bridges, not limited by end shear (par. 200*b*), can be strengthened by converting the center portion of spans to DD, TD, DT, and TT, respectively. Number of bays converted depends on the increase in load class. Added panels must be complete with bracing frames and tie plates; in triple-story construction, overhead bracing is also necessary.

b. CONSTRUCTION AND LAUNCHING. Partial story can be added before or after launching. When added before launching, use standard launching nose for complete bridge of the heavier construction if length of reinforcement is more than half the span. If length of reinforcement is half the span or less, use launching nose for standard bridge of the lighter construction.

c. CAPACITY TABLE. Table 61 gives safe capacities of bridges that can be reinforced with partial stories. Lengths of reinforcement with corresponding weight classes are shown as well as the capacity of the unreinforced bridge. Caution capacities are all 25 percent greater than the safe values.

Table 61. Safe capacity in tons of Fixed Panel Bridges Reinforced with Partial Stories

Span (feet)	DS		TS		DD		TD	
	Bays of DD	Capacity*	Bays of TD	Capacity*	Bays of DT	Capacity*	Bays of TT	Capacity*
80	0	51	0	80				
	4	60	4	85				
90	0	44	0	62				
	5	56	6	80				
	0	31	0	52	0	75		
100	6	51	4	59	4	80		
			6	80				
	0	23	0	40	0	64		
110	7	44	5	50	5	80		
			7	73				
	0	18	0	34	0	50	0	70
120	6	25	6	43	6	68	4	75
	8	38	8	63	8	80	6	80
	0	13	0	23	0	40	0	57
130	7	21	7	35	5	46	5	70
	9	38	9	55	7	60	7	80
					9	80		
	0	10	0	18	0	31	0	48
140	8	18	8	30	6	38	6	60
	10	31	10	48	8	51	8	80
					10	67		
			0	13	0	23	0	40
150			9	25	7	30	7	51
			11	39	9	42	9	70
					11	60	11	80
			0	10	0	19	0	31
160			8	14	8	26	8	43
			10	22	10	38	10	60
			12	31	12	53	12	80
					0	13	0	23
170					9	22	9	34
					11	33	11	52
					13	46	13	67
					0	10	0	18
180					10	18	10	30
					12	30	12	46
					14	39	14	57
							0	12
190							11	24
							13	38
							15	47

* Grillage must be checked to make certain it will carry increased load.

202. Reinforcement with Supplementary Chords

a. DESCRIPTION. All types of bridges except spans limited by end shear can be reinforced with supplementary chords cut from damaged

panels. The supplementary chords are pinned together and bolted to existing *top and bottom chords* with chord bolts. Bracing frames, modified to clear the chord bolts, must be used (fig. 194). Overhead bracing supports cannot be used with supplementary chords unless bolts 4 inches longer than standard chord bolts are used. If overhead bracing supports are not used, overhead transoms can be clamped under the top chord or welded on top of supplementary chords.

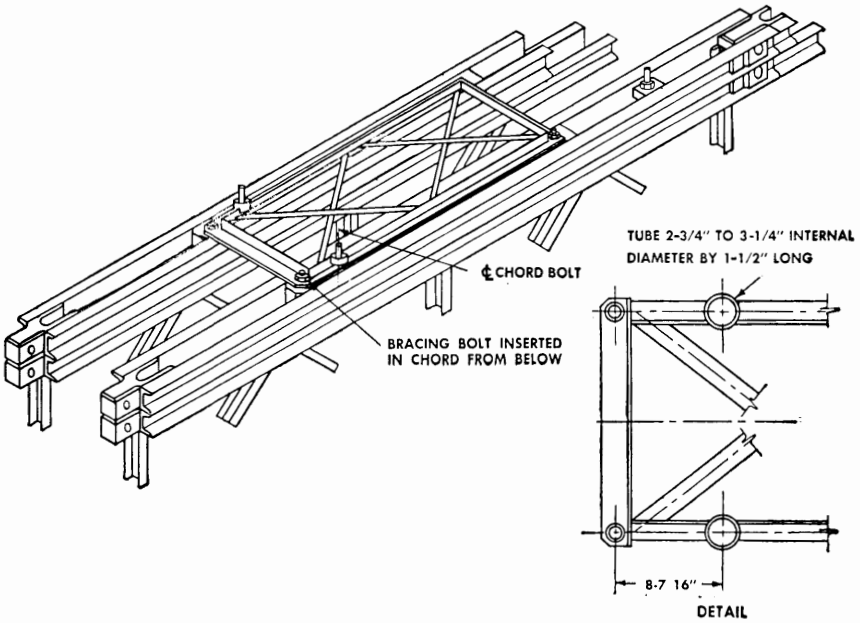


Figure 194. Supplementary chords and modified bracing frame.

b. SPECIAL PARTS. (1) *Supplementary chords* (fig. 194). Supplementary chords cut from salvaged panels must be straight and undamaged. The web channels must be burned off and ground smooth without damaging the chord channels. To use lower panel chords as top-chord reinforcement on all types of bridges, transom seats must also be carefully removed and ground smooth. A supplementary chord weighs about 200 pounds.

(2) *Modified bracing frame* (fig. 194). Horizontal bracing frames on double- and triple-truss bridges reinforced with supplementary chords must be modified to clear the projecting chord bolts. A tube, 1½ inches long and between 2¾ inches and 3¼ inches internal diameter, is welded into each longitudinal angle $8\frac{7}{16}$ inches from the bolt holes at one end of the frame. An improvised jig should be used to hold the bracing frame during cutting and welding to maintain alinement of the bolt holes. This modification does not prevent normal use of the bracing frame.

c. CONSTRUCTION AND LAUNCHING. Supplementary chords cannot be added to the lower chord before launching because projecting chord

bolts interfere with rollers. They can be added to upper chords, however, with no change in standard launching noses. Bracing bolts for fastening horizontal bracing frames must be inserted in supplementary chords before the chords are bolted to the truss. When chord bolts are tight, nuts are removed from the bracing bolts and bracing frames added (fig. 194).

d. CAPACITY TABLE. Table 62 gives the maximum safe capacity of bridges reinforced with supplementary chords and the corresponding length of reinforcement required. Capacities of the unreinforced bridges are also shown. Caution capacities are 25 percent greater than the safe values.

Table 62. Safe capacity in tons of fixed panel bridges reinforced with Supplementary Chords[1]

Span (feet)	SS		DS		TS		DD		TD		DT		TT	
	Bays of reinforcing	Capacity[2]	Bays of reinforcing	Capacity[2]	Bays of reinforcing	Capacity[2]	Bays of reinforcing	Capacity[2]	Bays of reinforcing	Capacity[2]	Bays of reinforcing	Capacity[2]	Bays of reinforcing	Capacity[2]
80	0	18	0	51	0	80								
	4	21	6	60	4	85								
90	0	13	0	44	0	62								
	7	18	7	56	5	80								
100	0	10	0	31	0	52	0	75						
	8	16	8	51	6	80	4	80						
110			0	23	0	40	0	64						
			9	48	7	75	7	80						
120			0	18	0	34	0	50	0	70				
			10	45	8	69	8	80	6	80				
130			0	13	0	23	0	40	0	57				
			9	40	9	57	9	80	7	80				
140			0	10	0	18	0	31	0	48				
			10	33	10	48	10	74	10	80				
150					0	13	0	23	0	40				
					11	40	11	60	11	80				
160					0	10	0	19	0	31				
					12	34	12	51	12	77				
170							0	13	0	23				
							13	43	13	63				
180							0	10	0	18				
							12	36	12	54				
190									0	12	0	31	0	47
									13	43	9	38	7	54
200											0	23	0	38
											12	34	10	48
210											0	18	0	29
											15	30	13	42

[1] Both upper and lower chord of bridge must *always* be reinforced.
[2] Grillage must be checked to make certain it will carry increased load.

CHAPTER 24

BRIDGES ON PIERS

Section I. GENERAL

203. Scope

This chapter describes multispan panel bridges using either continuous or broken spans.

204. Types of Construction

Wide gaps can be spanned by fixed panel bridges if intermediate supports are used to keep unsupported spans within allowable limits.

a. PIERS. Existing piers of demolished structures (fig. 195), panel crib piers (fig. 196), framed bents or cribs (fig. 197), pile piers (fig. 203), or combinations of these (fig. 198) are used for intermediate supports.

b. BRIDGE TYPES. Bridges are either broken over the piers, forming a series of simple supported spans, or are continuous. Spans are single, double- or triple-truss and single- or double-story construction. Triple-story construction generally is uneconomical.

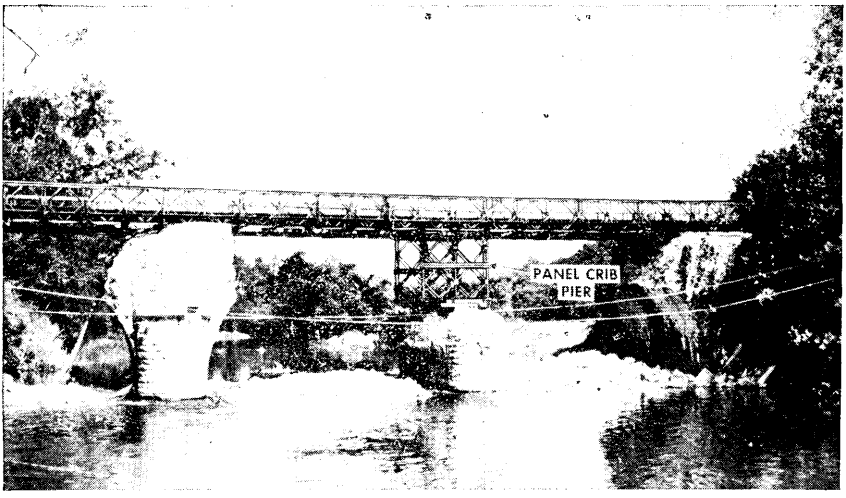


Figure 195. Continuous panel bridge supported on damaged masonry pier and a panel crib pier at St. Frambault, France.

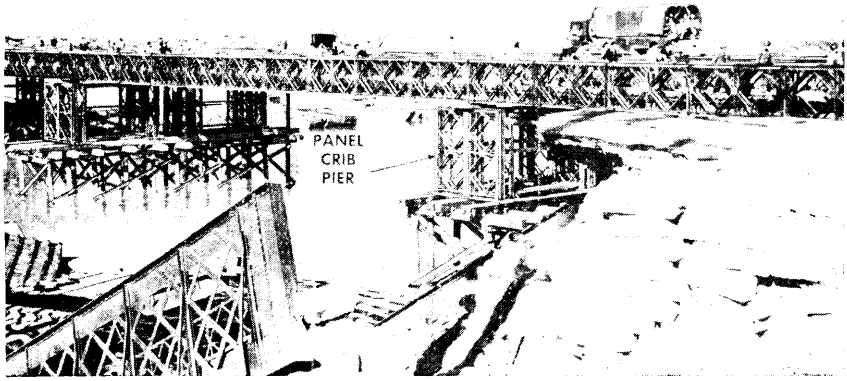


Figure 196. Fifth Army 440-foot TS continuous panel bridge on panel crib piers on piles over Arno River at Florence, Italy.

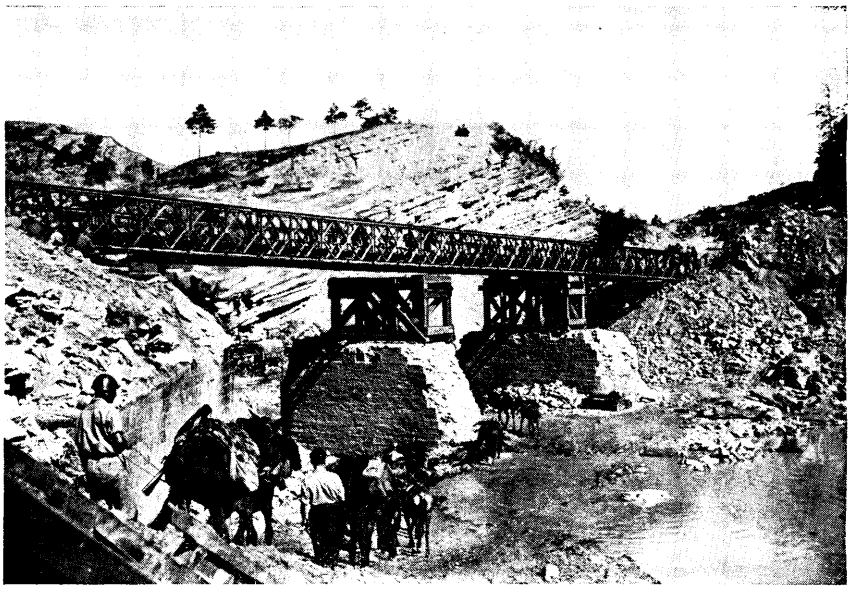


Figure 197. Fifth Army 170-foot DS continuous panel bridge supported on timber piers at Firenzuola, Italy. Near end of bridge is jacked up preparatory to inserting expedient bearings on near pier.

205. Publications on Related Topics

Number of publication	*Title*	*Topic*
FM 5–10	Construction and Routes of Communication.	Field design and construction of timber trestle and pile bents and piers.
TM 5–286	Semipermanent Highway and Railway Trestle Bridges.	Standard designs for timber and steel abutments, bents, and piers.
TB ENG 32.....	Piles and Pile Driving.....	Design and construction of pile bents and piers. Description of pile-driving equipment.

Section II. BROKEN-SPAN BRIDGES

206. General

Broken-span bridges are multispan structures with the top chord broken and the bottom chord broken or pinned at the piers. The two adjacent spans act independently under load. One advantage of broken-span over continuous-span construction is that reaction on intermediate piers is less.

207. Construction

a. SPANS. Independent spans can be single–, double–, or triple-truss and single- or double-story construction.

(1) If double-truss span is joined to triple-truss span or single-truss span is joined to double-truss span with span junction posts, junction links, and junction-link bearings (fig. 219), continue heavier construction for two end bays of lighter span to stabilize the junction link. Keep transom clamps in these bays tight.

(2) If a triple-truss panel crib pier supports a double-truss bridge, distribute the load to all trusses in the pier by triple-truss construction and double transoms over the pier and in three adjacent bays of each span.

b. PIERS. Any type of supporting crib or pier capable of taking end reactions of the spans can be used in the gap. Bailey-type panel crib piers for supporting broken-span bridges are described in chapter 25. For design of timber trestle and pile piers, see FM 5–10, TM 5-286, and TB ENG 32. It is desirable to make the top of all piers in the same plane as abutments, but a change in slope between spans may be used if needed. High narrow piers are guyed to prevent lateral movement.

c. BRIDGE SEATINGS. (1) *With panel-crib-pier parts.* If panel-crib-pier parts are available, seat ends of two adjacent spans on common



Figure 198. Fifth Army 470-foot DS continuous- and broken-span panel bridge at San Andrea, Italy. Piers consist of panel crib piers and steel cube cribs on the damaged masonry piers.

junction-link bearing (fig. 219). Attach span junction posts to end of each span, and pin posts to junction links fitting in junction-link bearings. Bridge gap between two spans with junction chess.

(2) *Without panel-crib-pier parts.* If panel-crib-pier parts are unavailable, attach end posts to ends of adjacent spans and seat on separate bearings (figs. 199 and 200). Use any of following three methods to bridge gap between spans:

(*a*) *Junction chess.* If junction chess are used, seat an extra transom in end posts of one span and space bearings 21¾ inches apart center to center (fig. 199).

(*b*) *Timber stringers and chess.* If junction chess are unavailable, use seventeen 4- by 4-inch timber stringers decked with two chess. If bearings are butted against each other (fig. 201), the stringers must be 2 feet long.

(*c*) *Cut stringers.* Standard stringers cut to the desired length can be used to bridge the gap between spans.

(*d*) *Standard stringers and chess.* If bearings are spaced 4 feet 6⅞ inches center to center, bridge gap by setting standard panel-bridge stringers back 5 feet along bridge (fig. 202). Use extra panels to support overhanging stringers at one end of bridge.

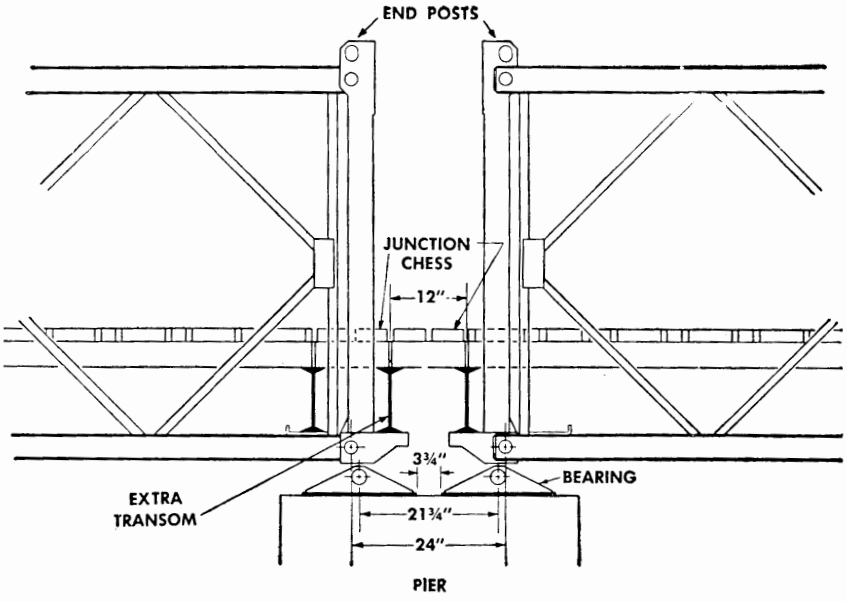


Figure 199. Bearings on pier at adjacent ends of two intermediate spans. Junction chess bridge the gap between spans.

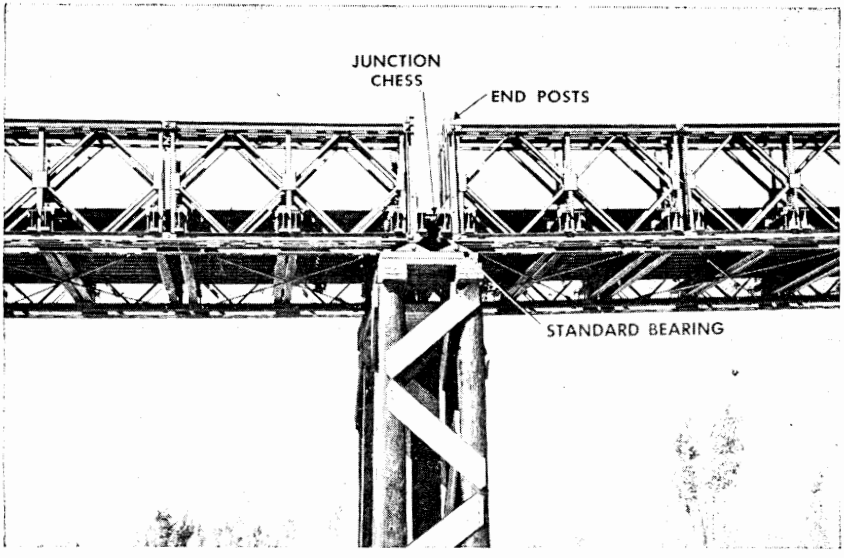


Figure 200. Adjacent ends of independent spans seated on bearings on pile pier. Junction chess bridge gap between spans.

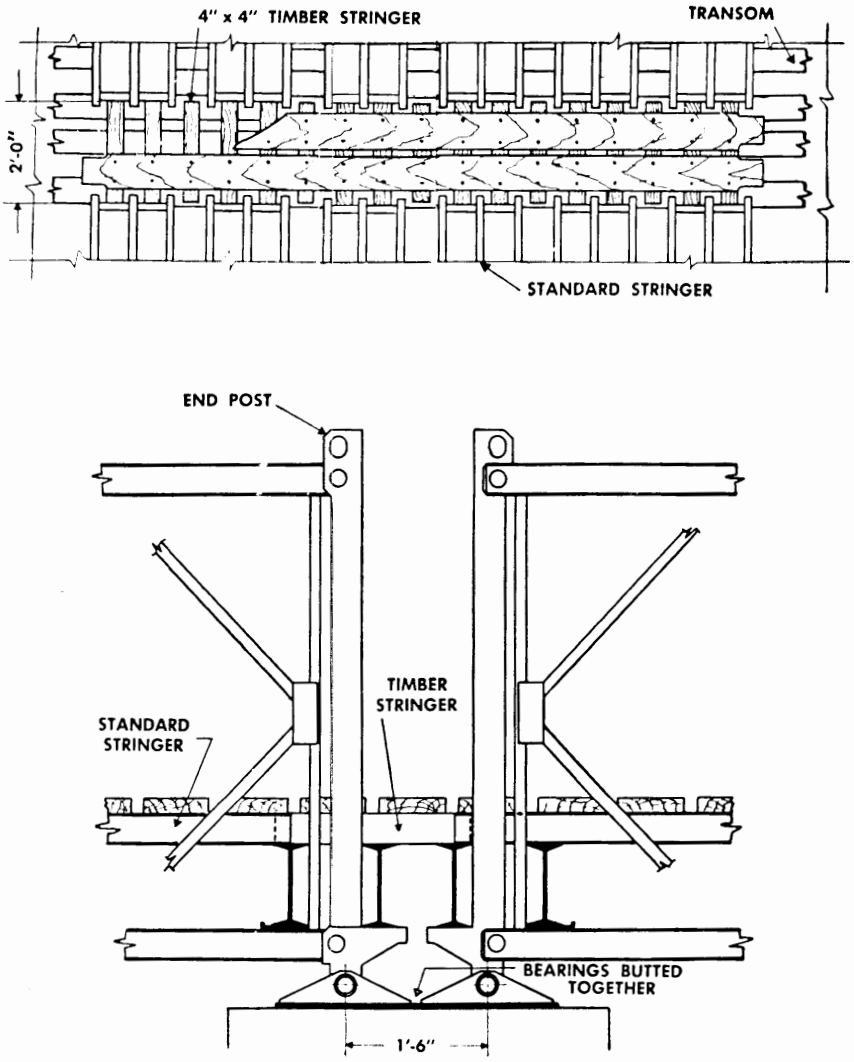


Figure 201. Use of 4- by 4-inch stringers 2 feet long to fill gap between ends of spans.

(3) *Without end posts.* If end posts are not used, fasten steel plates to pier cap for truss bearings. Pin only lower chords of spans. Omit top pin at junction so two spans can act independently (fig. 203).

(4) *On timber trestle or pile bents.* If timber trestle or pile bents are used as intermediate piers, construct top of bent as shown in figures 204 and 205. If end posts are not used, reinforce cap sill with steel bearing plate under each line of trusses. On single bents, use corbels with knee braces to provide a jacking platform for light bridges

(fig. 204②). If double bents are used with end posts and standard bearings, lay timbers across caps to provide platform for seating bearings (fig. 205). Group timbers together under each line of trusses.

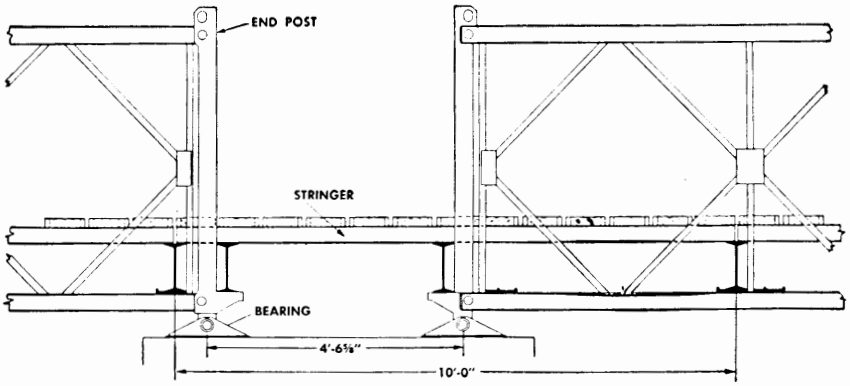


Figure 202. Two spans supported on a common pier. Gap of 5 feet left between ends of spans is bridged by offsetting stringers.

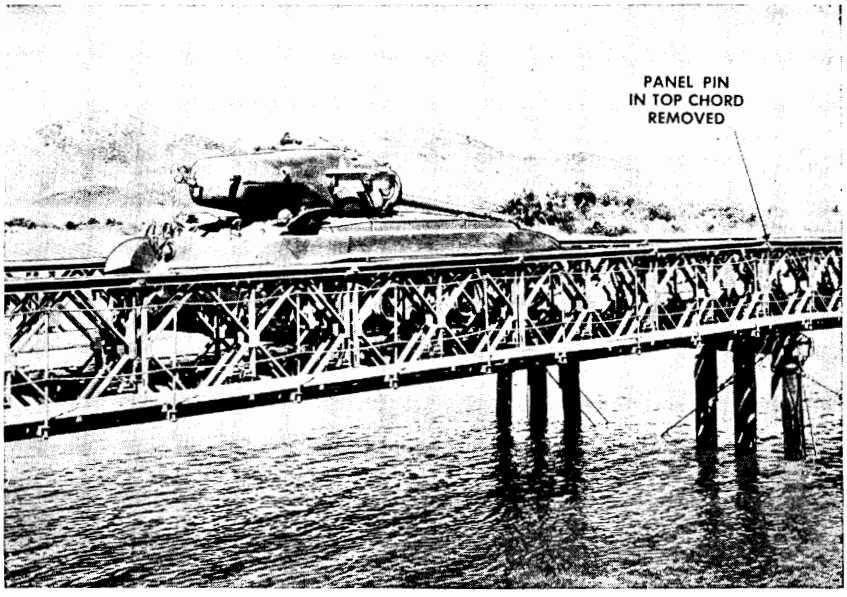
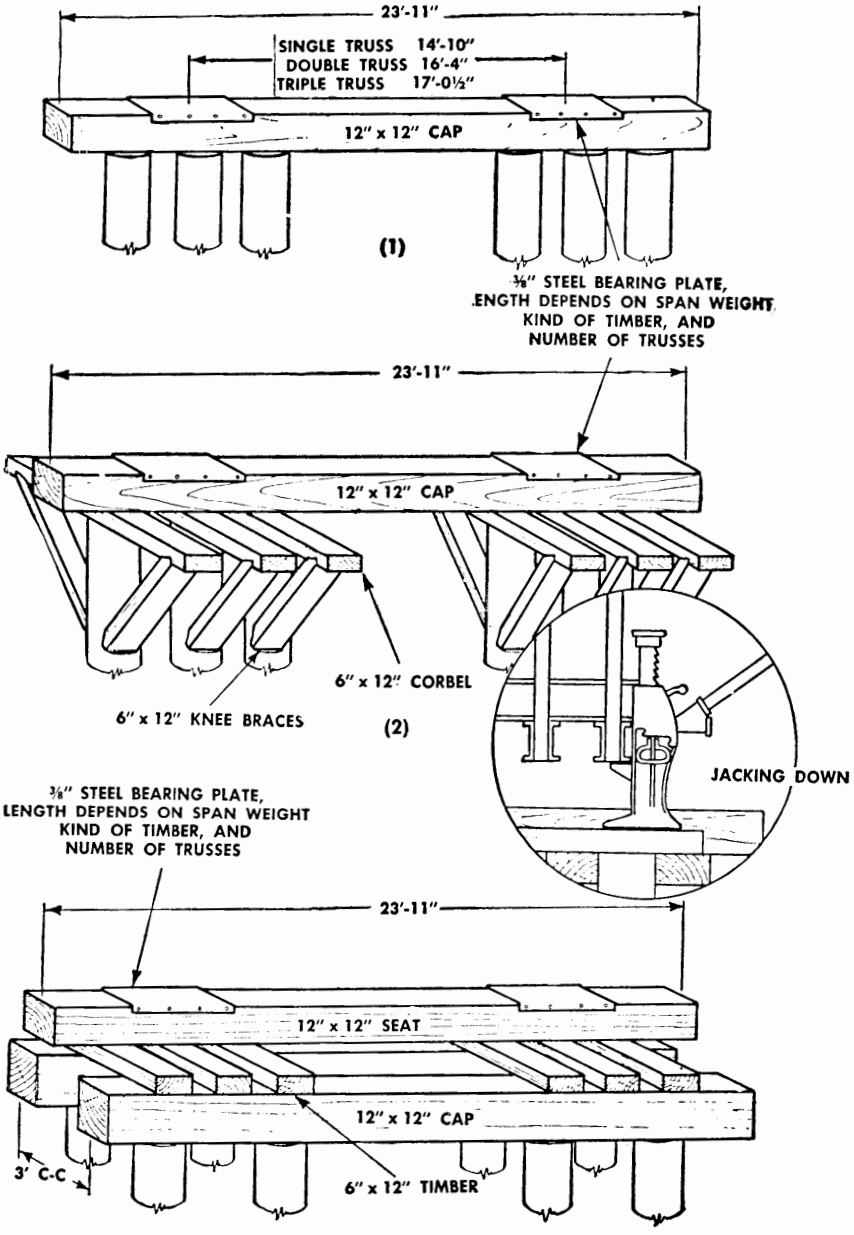


Figure 203. Junction of independent spans without end posts over pile bent. Bottom chords are pinned together and set on bearing plate on pier cap sill. Panel pin is left out of top chord so two spans act independently.

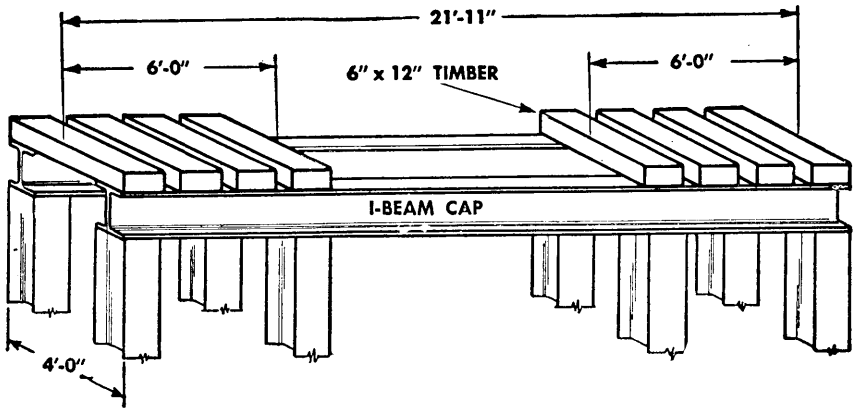


①*Cap for single timber or pile bent. Steel bearing plates provide seating for each line of trusses.*

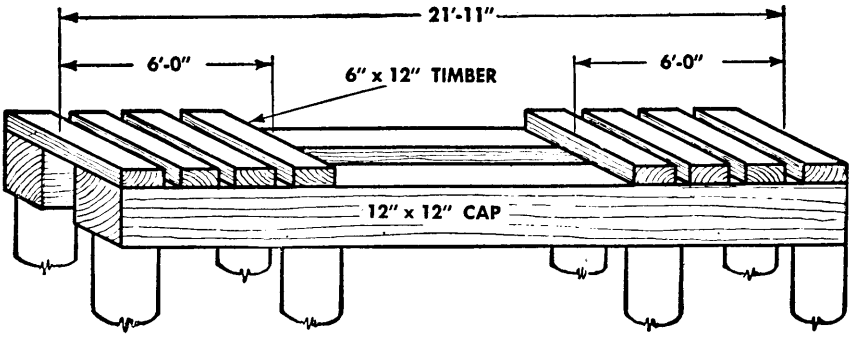
②*Corbels and knee bracing added to provide a jacking platform for light bridges.*

③*Cap for double trestle or pile bent.*

Figure 204. Construction of pile caps for intermediate supports under panel bridges without end posts or bearings.



(1) STEEL PILES AND CAPS



(2) WOOD PILES OR TRESTLE AND CAP

Figure 205. Construction of pile caps to provide seating for bearings at adjacent ends of independent spans.

208. Capacity

a. NORMAL SPANS. Since spans of a broken-span bridge act independently, each span has the same capacity when fitted with end posts or span junction posts as a simple-span bridge of the same span length and type of construction. For capacities of panel bridges, see chapter 4.

b. SPANS WITHOUT END POSTS. If end posts or span junction posts are not used, the capacity of spans is limited. For capacities of panel bridges without end posts, see chapter 27.

c. PIERS. (1) In a series of broken spans, the capacity of the weakest span is the capacity of the bridge if the piers are strong enough to carry the reactions. For capacities of panel crib piers, see chapter 25; for pile piers, see TB ENG 32; for timber trestle bents and piers, see FM 5-10 and TM 5-286.

(2) The load on a pier from two adjacent independently supported spans is computed by the following formulas. These formulas are based on a vehicle spacing of 90 feet, allowing 30 percent of live load for impact and eccentricity. These formulas do not apply if either span is over 180 feet.

$$R_1 = 1.3P + \tfrac{1}{2}W_d$$

$$R_2 = 1.3P\ \frac{(1 + L_1 - 90)}{L_1} + \tfrac{1}{2}W_d$$

$$R_3 = 1.3P\ (1 + \frac{L_1 - 90}{L_1} + \frac{L_2 - 90}{L_2}) + \tfrac{1}{2}W_d$$

Where:

R_1 = load in tons on pier when *both* spans are *under* 90 feet.

R_2 = load in tons on pier when one span is 90 feet or *over* and *other* span is *under* 90 feet.

R_3 = load in tons on pier when *both* spans are 90 feet or *over*.

P = bridge class in tons (maximum allowable live load).

W_d = total dead weight of two spans (see table 1 for weight per bay of panel bridges).

L_1 = length in feet of longer span.

L_2 = length in feet of shorter span.

209. Methods of Launching

Broken-span bridges are launched by cantilevering the entire bridge with launching nose over the gap as a continuous bridge and breaking it at the piers; by launching each span by single girders; or by floating each span into position.

210. Launching as a Continuous Bridge

a. GENERAL. Normally, an entire single- or double-story bridge with nose is launched over intermediate piers and then broken at the piers. Long heavy single- or double-story bridges can be launched incomplete to make the launching easier. Connect the spans directly or by span junction posts and launching links. Push the bridge across the gap or pull it across by a winch line. In general, the following procedure applies in launching as a continuous bridge. Various techniques are discussed in *b*, *c*, and *d* below.

(1) *Launching rollers.* Place launching rollers on each pier and on abutments in the same horizontal plane. Spike or lash rocking-roller bearings, base plates, or templates to piers to prevent shifting during launching. When span junction posts are not used and the bridge is to be cut over the pier, the pier top must be wide enough to allow the placing of two rocking rollers end to end under each truss.

(2) *Launching nose.* Use a launching nose in the same manner as for a normal bridge. The length of the launching nose should be the same as required for a single span bridge of the same length as the

longest span in the broken-span bridge. Use launching-nose links in bottom chords of nose to compensate for sag. When estimating sag in nose to determine position of links, allow an extra 12 inches of sag for safety.

(3) *Guying piers.* During launching, guy piers to offset longitudinal thrust of bridge. When completely launched, pull bridge back slightly to relieve stress in guy lines if necessary.

(4) *Jacking beams.* Jacking down over intermediate piers requires jacking beams similar to those described in paragraph 218.

b. SPANS WITH SPAN JUNCTION POSTS ON JUNCTION-LINK BEARINGS. The following is the procedure for spans with span junction posts on junction-link bearings.

(1) *Making junctions.* Fit span junction posts to ends of spans and pin bottom jaws of adjacent posts together.

(*a*) If spans are all the same length, begin with first junction and fit alternate junctions with launching links between tops of span junction posts. This makes bridge continuous at these points. These junctions are called locked junctions. Do not connect top chords at other junctions.

(*b*) If spans are not all the same length, make first length of continuous bridge plus launching nose twice the length of the longest span. This counterweights the nose over the gap.

(*c*) In double-story construction, place span junction posts in each story. Pin the bottom jaws of posts in lower story together and use Mk II launching-nose link to connect top of posts in top story. Do not make a pin connection between posts at top of lower story and bottom of top story.

(2) *Removing pins and jacking down.* Following are two methods of removing launching-nose links from top chords at locked junctions:

(*a*) *Removing launching-nose links at point of contraflexure.* For bridges with several long heavy spans, launching-nose links are removed at the point of contraflexure. In a continuous girder, there is a point near each support where the girder changes from a downward sag in the gap to an upward bend over the pier. At this point (point of contraflexure), there is no bending moment in the girder, no stress in links in the top chord, and panel pins are easy to remove. If the pins are heavily greased, they can be pulled by hand. To find the point of contraflexure in the span, station men at each link to test pins for slackness as soon as links are one-third span length from far pier. Push bridge ahead slowly and continue to test pins. When pins are loose, remove links. After removing links, continue launching until bridge is in final position over piers. Then, jack down bridge simultaneously at alternate supports.

(*b*) *Removing launching-nose links over piers.* For short light bridges of two or three spans, launching-nose links are removed over piers. Launch bridge completely before attempting to remove links. After

launching, jack up ends of bridge and substitute cribbing at same height as rocking rollers at abutments. Then, remove rollers and cribbing at each center pier and jack bridge down slowly. As jacks at center pier are lowered, tension in top chord decreases. When tension is zero, remove pins in Mk II links. Then, jack bridge down on center pier. Repeat this procedure at adjacent piers, working toward abutments.

c. Spans with End Posts on Standard Bearings. Following is the procedure for spans with end posts on standard bearings:

(1) Launch as a continuous bridge until far span is in position.

(2) Disconnect far span from rest of bridge, and pull bridge back until next span is in position. To remove the pins the bridge may be jacked up slightly either at the junction or at the end.

(3) Repeat this procedure until all spans are disconnected over their piers.

(4) Pin end posts to ends of spans, and jack spans down on bearings.

d. Spans Without End Posts. Following is the procedure for spans without end posts:

(1) If bottom chords of all spans are to be pinned together and only top chords broken at piers, make junctions, launch bridge and remove pins in same manner as for spans with span junction posts (*b*(2) above).

(2) If both top and bottom chords are to be broken at piers, launch bridge in same manner as for bridge with end posts (*c* above).

211. Launching by Single Girders

In launching by single girders, build bridge by launching girders of each span from deck of previously completed spans. Add transoms and decking after girders are in place. For detailed procedure, see chapter 29.

212. Launching by Flotation

In launching by flotation, the span is constructed on rollers on the shore, launched onto pontoons or rafts, and floated into position between the piers. For detailed procedure, see chapter 31.

213. Maintenance

Periodic checks are made to record any sinking of piers. Cribbing and wedging are used to keep bearings at the same elevation. Lateral shifting of the bridge is prevented by timber blocking on each side of bearings and lateral guy lines on high piers.

Section III. CONTINUOUS-SPAN BRIDGES

214. General

A continuous-span bridge is one in which both upper and lower chords

are continuous over intermediate piers between abutments. Advantages of continuous-span bridges are that siting of piers is not limited to 10-foot increments by panel junction as in broken-span bridges, construction is faster, and capacity is increased for most types of construction.

215. Construction

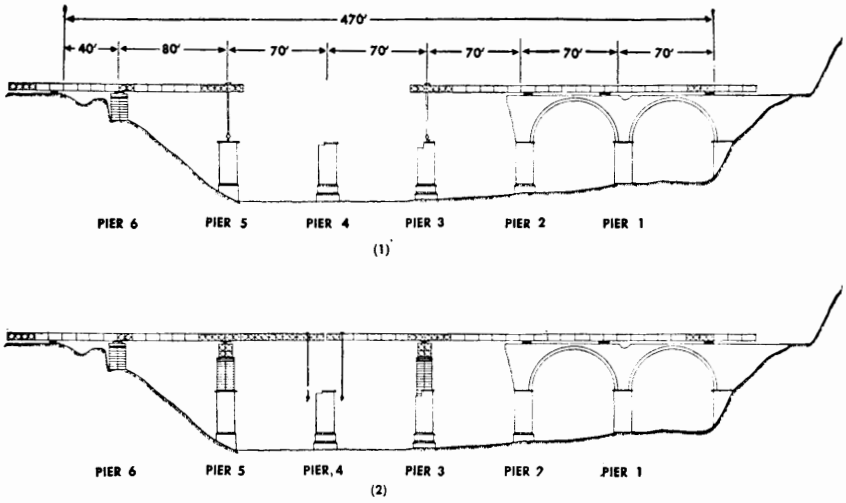
a. Number of Spans. Number of spans is limited by two factors—effect of harmonious vibration set up by loads, and difficulty of keeping long bridges in alinement during launching. Normally, continuous-span bridges are limited to 4 spans or 500 feet.

b. Length of Spans. The maximum span in a continuous-span bridge to carry a specified load is given in table 63. The short span *must* be at least 60 percent of the length of the longer adjacent span. If the short span is less than 60 percent, a heavy load on the long span raises the end of the short span off its bearing. If spans less than 60 percent are essential, break the bridge at the pier to make the short span independent.

c. Change of Construction Over a Pier. Changes in truss construction are avoided when possible. If changes must be made, change number of stories rather than number of trusses to give better redistribution of stresses between adjacent spans. Extend heavier construction of longer span beyond intermediate pier a distance equal to 25 percent of shorter span. Make only the following changes of construction between spans:

SS to DS
DS to DD
TS to TD
DD to DT

d. Construction of Piers. Any type of supporting crib or pier capable of taking the reactions of the spans can be used. Piers are normally built before the bridge is launched over them. Where piers are inaccessible from the ground because of extreme height or rapid stream, a high line can be used in construction or the men and materials can be lowered from the end of the cantilevered launching nose of the bridge. Figure 206 illustrates how this was done on the San Andrea bridge over the Santerno River, Italy. On two-span bridges, the bridge may be launched across the gap and the pier parts lowered from the bridge (figs. 207 and 263). The capacity of the bridge over the combined gap must be checked to insure that it will carry the pier construction crew and materials. High narrow piers are guyed to prevent lateral movement.



①*Piers 3 and 5 constructed from ends of bridge cantilevered out from each bank.*
②*Pier 4 constructed from ends of bridge cantilevered out from each bank.*

Figure 206. Construction of intermediate piers of San Andrea bridge.

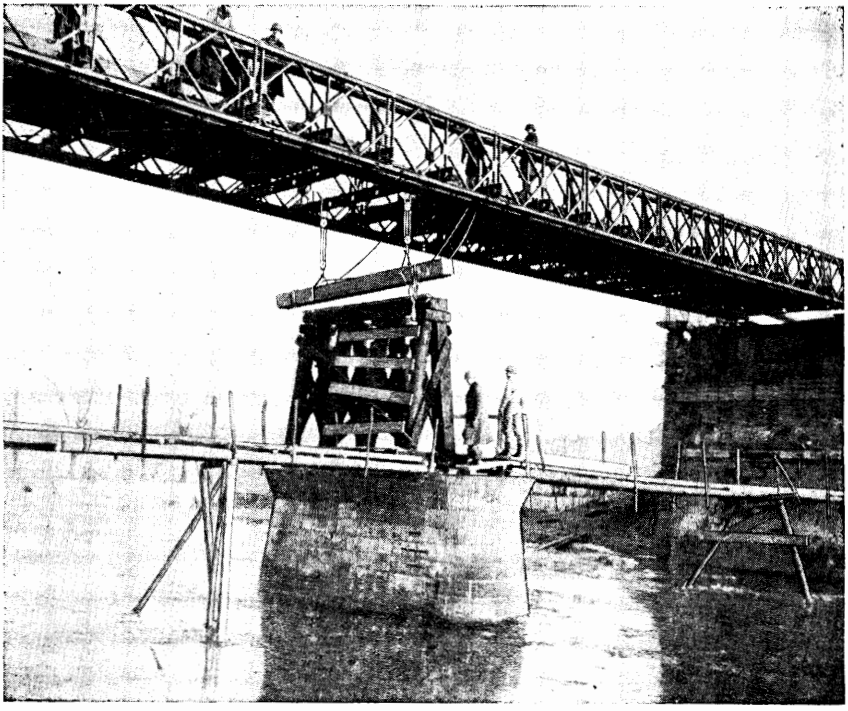


Figure 207. Constructing timber trestle by lowering materials from bridge over combined gap at Noiseux, Belgium.

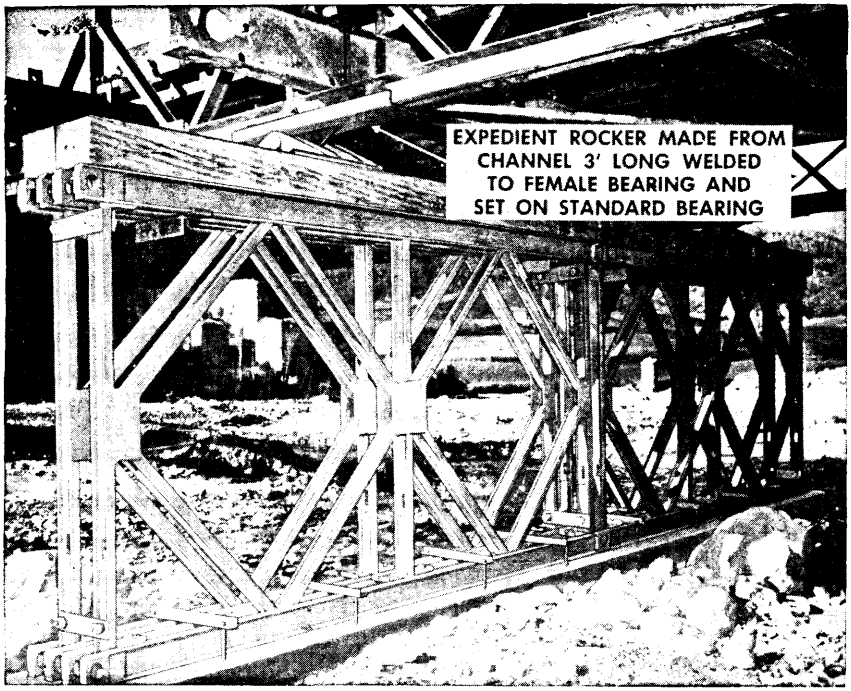


Figure 208. Rocker bearing to support one panel support point made from female bearing welded to 3-foot length of 8-inch channel.

c. CONSTRUCTION OF BRIDGE SEATING. Some form of rocker bearing must be used at the intermediate pier to allow for deflection of girders under load. Normally, a rocker bearing for the bridge is placed at the top of the pier. If a rocker is placed at the base of the pier, the bridge can be fastened rigidly to the pier (ch. 25). Various types of rockers at top of pier are described below. The distributing beam on the rocker bearing must be strong enough to prevent excessive local bending in the bottom panel chord. Table 64 gives the number of panel support points (points under panel verticals and junctions of panel diagonals) that must be effectively supported by the distributing beam to prevent excessive bending stress in the bottom chord.

(1) *Rockers to support one panel support point.* These rockers can be used only for light bridges and must be placed under a panel vertical or the junction of panel diagonals.

(*a*) Use two transoms on top of pier as shown in figure 243. Bottom bridge chord rocks directly on the transoms.

(*b*) Weld a 3-foot length of 8-inch channel to a female bearing (U-shaped lug) which rocks on a standard bearing. The bottom bridge chord is cradled in the channel (fig. 208).

(2) *Rocker to support two panel support points.* Use a crib capsill, crib bearing, and standard bearing from the panel-crib-pier set as illustrated in figure 209. Because of the flexibility of the crib capsill, this rocker gives full support to only two panel support points.

(3) *Rocker to support three panel support points.* Use a crib capsill, an inverted junction-link bearing, and a junction link from the panel-crib-pier set as illustrated in figure 210.

(4) *Rocker to support four panel support points.* Weld small transverse I-beams (cut from stringers) under panel verticals and diagonal junctions (panel support points) to give lateral stability and to load panels at strong points. Also weld these I-beams to 8-foot 4-inch transom sections which are parallel to the bridge chords and transmit the load over a number of panel support points. These transoms then rock on two transverse transoms which are fixed to the top of the pier. (See fig. 211.)

(5) *Rocker to support five panel support points.* Reinforce the crib capsill in figure 209 with an 8-foot 4-inch section of transom as illustrated in figure 212. Weld capsill, transom, and crib bearing together and pin by chord clamps to panel chord. Weld small channels across bottom of transom sections at each side of bridge to give lateral stability to each rocker. The crib capsill may be omitted if a 10-foot section of transom is used.

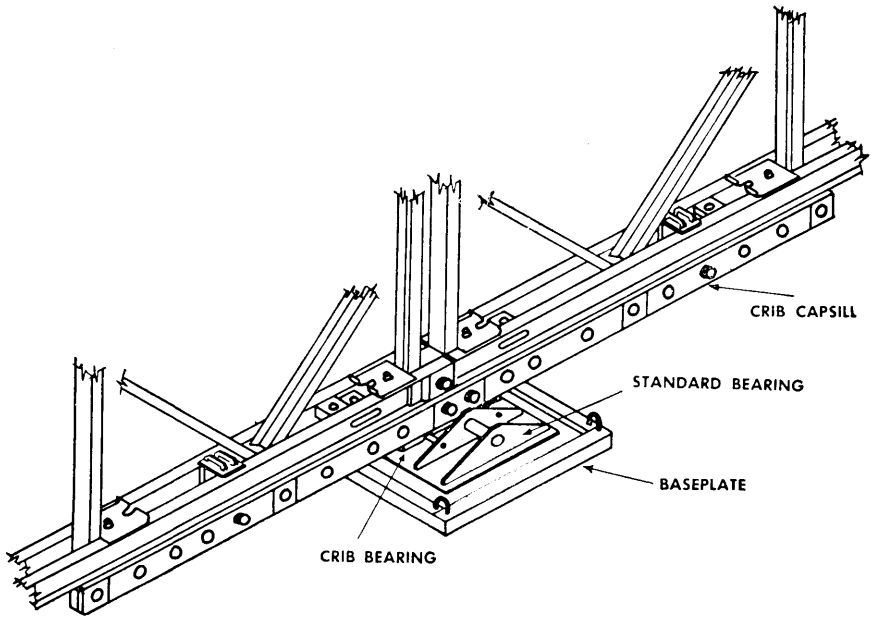


Figure 209. Rocker bearing to support two panel support points made from crib capsill, crib bearing, and standard bearing.

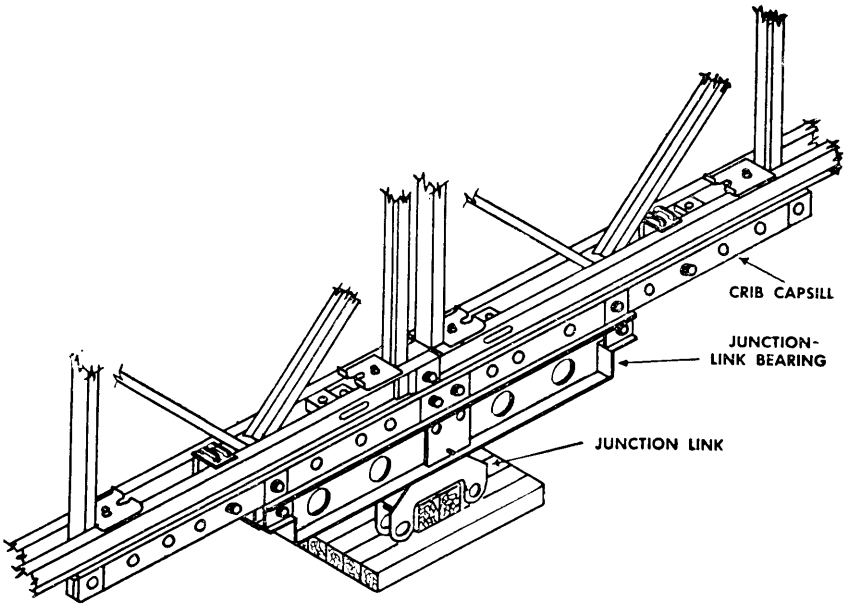


Figure 210. Rocker bearing to support three panel support points made from crib capsill, inverted junction-link bearing, and junction link.

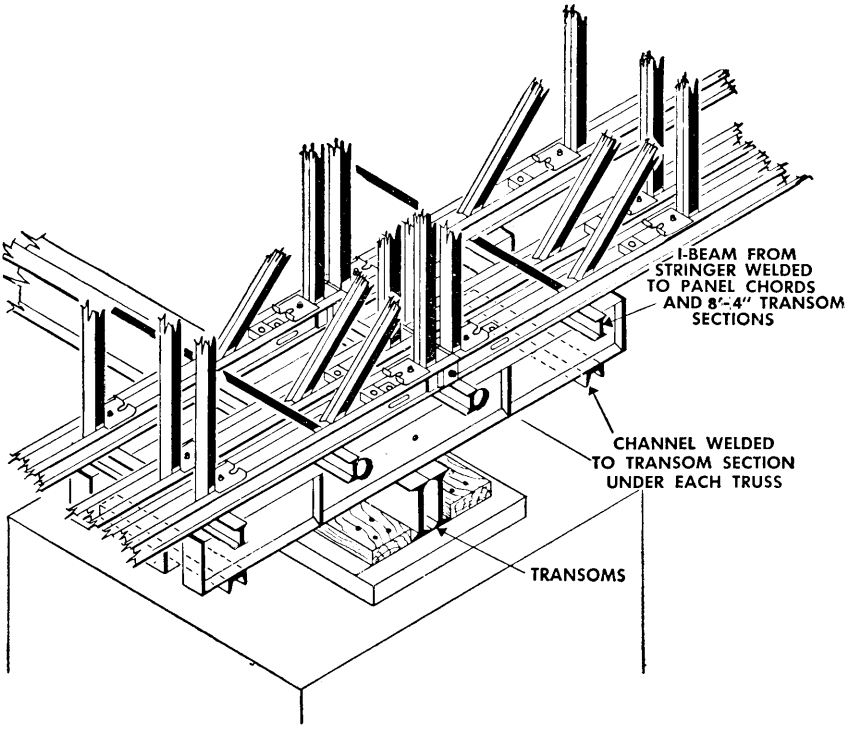


Figure 211. Rocker bearing to support four panel support points made from transoms and stringers.

f. ANCHORING BRIDGE. Allowance must be made for slight longitudinal movement of the bridge due to deflection under loads and expansion and contraction due to temperature changes. With temperature changes of 60° F., a movement of ½ inch per 100 feet of bridge can be expected. To allow for this movement, grease base plates so bearings can move longitudinally on them. Restrain the bearings laterally with timber guides. If sloping bridges are erected, alternate expansion and contraction makes the bridge creep downhill. To offset this, keep slopes under 40 to 1 and fix one end of bridge to prevent creeping. At end of a bridge with a short end span, lash or clamp end posts to bearings so posts cannot jump their seatings if end of bridge lifts when a heavy load is on second span.

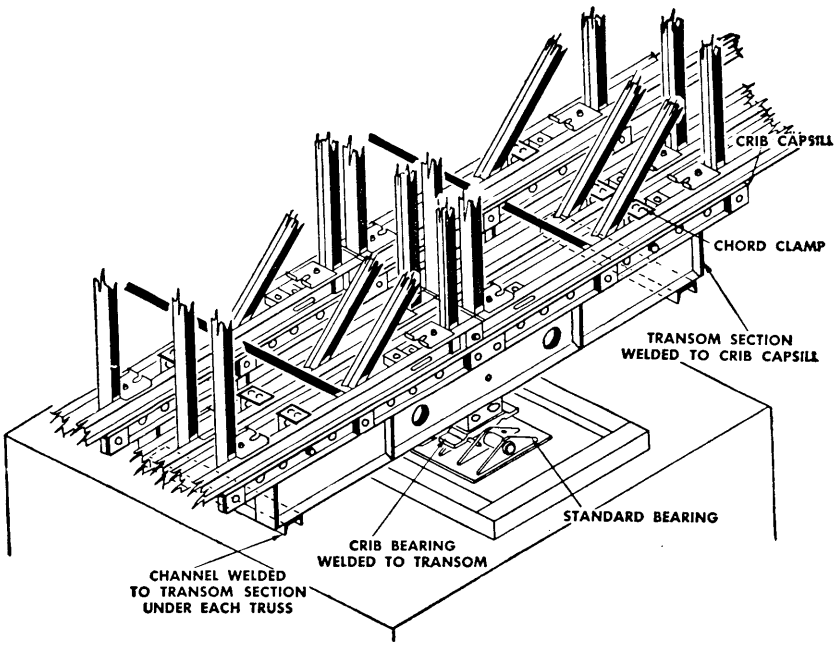


Figure 212. Rocker bearing to support five panel support points made from crib capsill, transom section, and crib bearing.

g. LEVELING SUPPORTS. The bottom chord of the bridge must be in the same plane over all the intermediate supports. Normally, this plane is level, but a slight inclination is permissible.

216. Capacity

a. The capacity of continuous-span bridges varies with span lengths. For shorter spans it may be less than that of broken-span bridges because shear at the piers is greater. Table 63 gives the capacities of

continuous-span bridges. Table 64 gives pier reactions and the number of panel points (points under panel verticals and junctions of panel diagonals) that must be supported by the rocker-bearing distributing beam to distribute stresses in bridge panels over the pier. The rocker bearing illustrated in figure 212 has a distributing beam long and stiff enough to support five panel support points and suitable for any of the spans in the tables.

b. An example of the use of the table is as follows:

Given:

1. Spans of 100 and 130 feet respectively on each side of an intermediate pier.
2. Continuous panel bridge to span these gaps must carry class 60 loads.

Required:

1. Determine bridge construction needed.
2. Determine type of rocker bearing to use.
3. Determine load on pier.

Solution:

1. *Construction*: 100-foot TS and 130-foot TD panel bridges will carry class 60 loads. TD construction must be carried three bays into the TS span (see construction rule 2 in table 64).
2. *Rocker bearing*: Three panel support points must be supported by rocker bearing (see legend B in table 64; use bearing illustrated in figure 210).
3. *Load on pier*: Load on pier from two 100-foot class 60 TS bridges is 134 tons; load from two 130-foot class 60 TD bridges is 212 tons. Average of two is 173 tons which is load on pier at junction of 100-foot TS and 130-foot TD bridge (see legend A in table 64).

217. Methods of Launching

Continuous-span bridges are launched by cantilevering the entire bridge with launching nose over the gap or by floating intermediate spans into position and then pinning.

a. With Launching Nose (fig. 213). Length of launching nose required is the same as for simple-span bridge of the same length as the longest span in the continuous-span bridge. Use launching links to compensate for sag. When estimating sag in nose to determine position of links, allow an extra 12 inches of sag for safety. The launching procedure is as follows:

(1) Use plain rollers as in a single-span bridge. Place rocking rollers at each abutment and on top of each intermediate pier. Place rollers on intermediate piers in the same plane as near- and far-shore

rollers, and spike or lash them to piers. Check level and alinement of rollers before starting bridge construction.

(2) For long bridges, mechanical power may be needed to launch the bridge. Use methods described in paragraph 122*b*. In addition, or as an alternative, use winch on far shore to pull bridge across gap. Careful alinement of bridge during early stages of launching is important.

(3) Long, heavy bridges can be launched incomplete to make the launching easier. Add extra trusses and decking needed to complete bridge after it is launched.

(4) During launching, guy piers to counteract forward thrust of launching. When bridge is completely launched, pull back slightly to relieve stress in guy lines if necessary.

Table 63. Safe Capacity for Continuous Panel Bridge M2 in tons

Span	Construction						
	SS	DS	TS	DD	TD	DT	TT
30	34						
40	27						
50	24	82					
60	22	66					
70	19	59					
80	17	50	84				
90	16	48	76				
100	14	39	66	92			
110	.....	30	51	76	100		
120	.....	22	38	63	90		
130	.....	17	29	53	74	100	
140	.....	13	23	40	62	84	
150	.....	.....	17	31	52	76	
160	.....	.....	13	24	39	69	94
170	.....	.....	.....	18	30	62	86
180	.....	.....	.....	13	21	48	76
190	.....	.....	.....	.....	14	34	58
200	.....	.....	.....	.....	.....	.....	41

Table 64. Data for Continuous Panel Bridge M2

Span		Construction						
		SS	DS	TS	DD	TD	DT	TT
30	A	45						
	B	2						
40	A	42						
	B	2						
50	A	43	105					
	B	2	2					
60	A	45	94					
	B	2	2					
70	A	46	92					
	B	2	2					
80	A	48	88	128				
	B	2	2	2				
90	A	53	93	127				
	B	2	2	2				
100	A	57	95	134	172			
	B	2	2	2	3			
110	A	.....	93	128	169	233		
	B	.....	2	2	3	3		
120	A	.....	89	121	165	221		
	B	.....	2	2	3	3		
130	A	.....	87	116	161	212		
	B	.....	2	2	3	3		
140	A	.....	87	113	152	206	250	
	B	.....	2	2	3	3	4	
150	A	.....	.....	113	148	206	254	
	B	.....	.....	2	3	3	4	
160	A	.....	.....	112	146	198	262	342
	B	.....	.....	2	3	3	4	4
170	A	.....	.....	.....	143	194	265	349
	B	.....	.....	.....	3	3	4	4
180	A	.....	.....	.....	141	185	251	349
	B	.....	.....	.....	3	3	4	4
190	A	.....	.....	.....	.....	179	234	336
	B	.....	.....	.....	.....	3	4	4
200	A	.....	.....	.....	.....	.....	.....	308
	B	.....	.....	.....	.....	.....	.....	4

A = Pier reactions (tons) at junction of two equal spans. Reaction at junction of unequal spans is average of reactions tabulated for two equal spans of each span length.

B = Number of panel support points to be supported by rocker bearings.

Construction Rules:

1. Length of one span should be at least 60 percent of adjacent span.
2. The heavier construction of a longer span must extend beyond the intermediate pier at least 25 percent of the length an adjacent shorter span.
3. Only the following changes of construction are permissible at an intermediate pier:
   SS to DS DS to DD TS to TD DD to DT

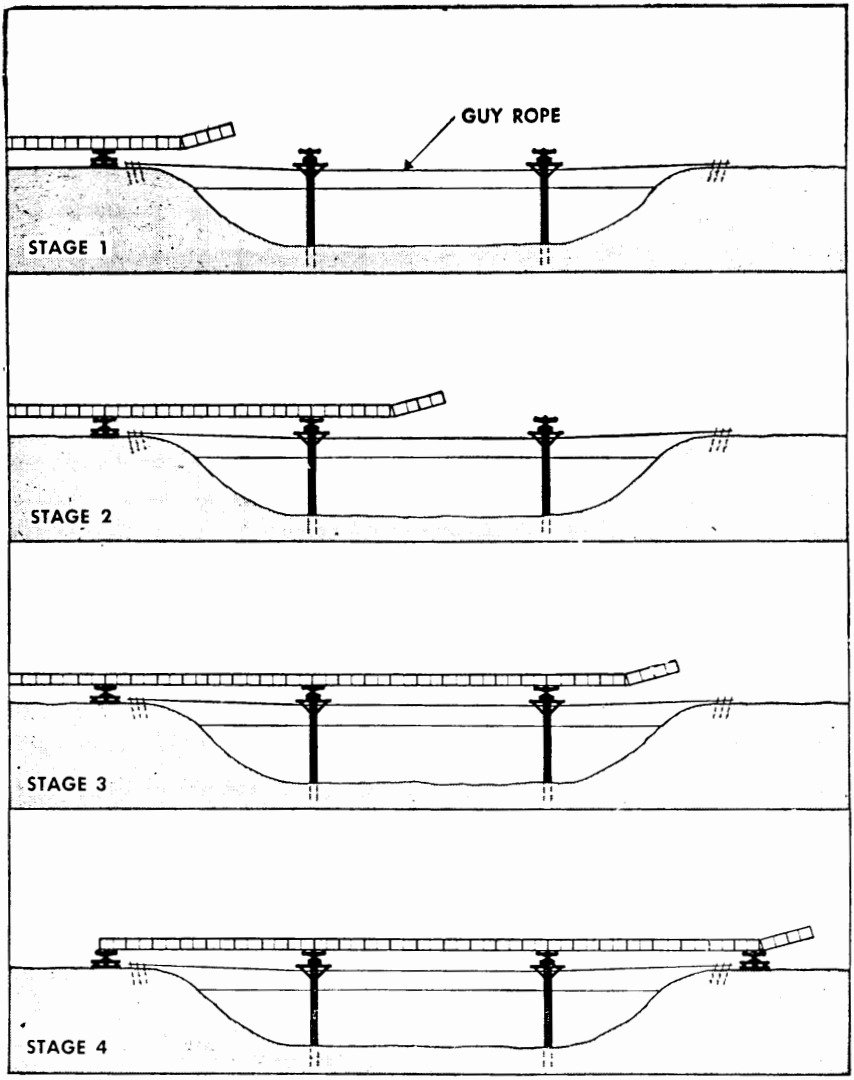


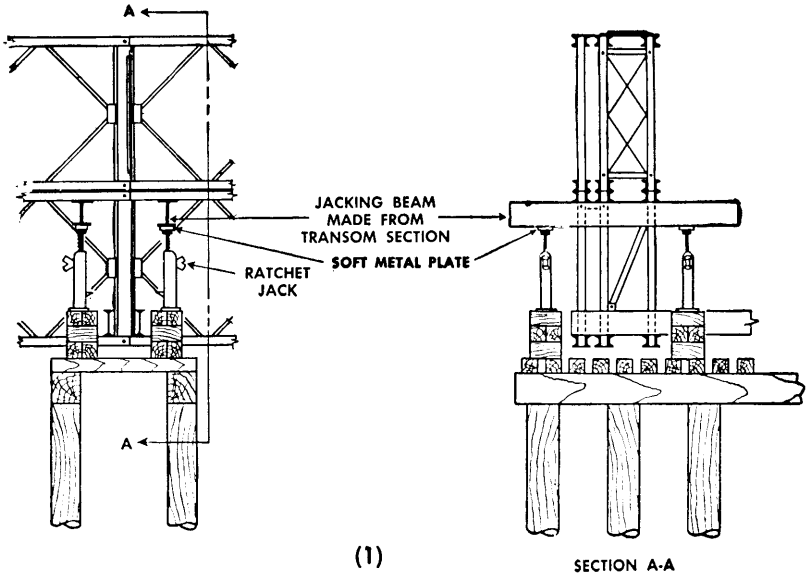
Figure 213. Launching a continuous-span bridge over intermediate supports with launching nose. Note guy line used to stabilize supports during launching.

b. By Flotation. Float intermediate spans into position as described in chapter 31. Lower and then pin to adjacent spans.

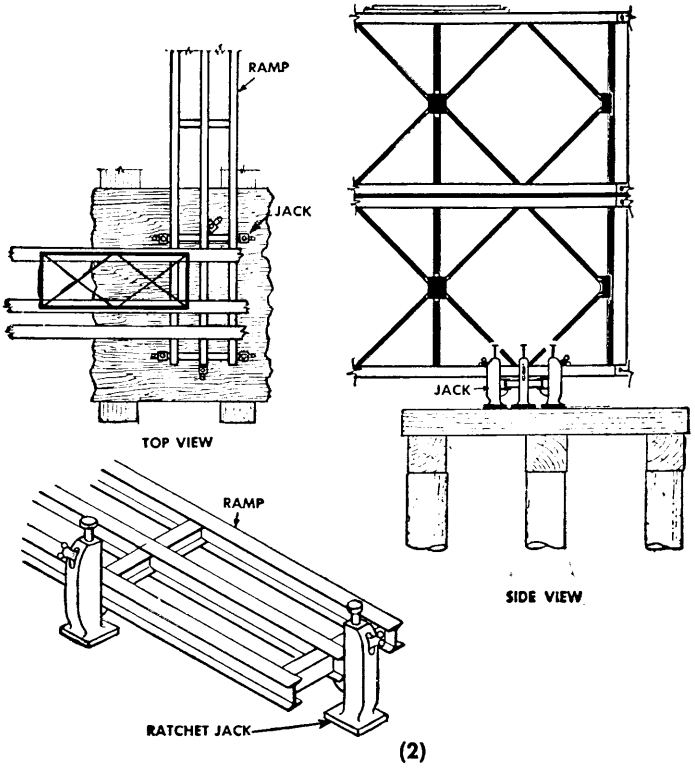
218. Methods of Jacking

a. Shore Ends. Jack down shore ends of bridges with jacks under end posts as described in chapter 11.

b. Intermediate Piers. At intermediate piers, expedient jacking methods must be used. Jacking load on *toe* of each jack must not exceed



(1) *Two jacks, one on each side of girder, push on beam under top chord of lower story.*



(2) *Six ratchet jacks arranged under ramp section under lower chord of trusses.*

Figure 214. Jacking over intermediate pier.

7½ tons; jacking load on *top*, 15 tons. Also, jacks operated in unison must be of the same manufacture. Figure 214 illustrates two methods of jacking at intermediate piers. Tables 65 and 66 give lengths of adjacent spans of continuous-span bridge that can be jacked with these arrangements.

(1) Use two jacks, one on each side of trusses, under a section of transom under the top chords of the lower story (fig. 214①). A soft metal plate between the jack head and the transom eliminates danger of jack head slipping. Place transom section close to verticals of panels. Block under jacks to raise transom sections to level of top chord.

(2) Another method is to arrange six jacks under ramp section placed across under side of bottom chords (fig. 214②).

219. Maintenance

Pier sinking causes increased stress in the bridge and must be checked immediately by blocking or wedging under bridge bearings. Check ends of short spans for any tendency to lift off bearings. If end posts do lift off bearings, lash posts to bearings or break short end span at pier. Check anchorage to keep bridge from creeping under traffic. Maintain blocking tc prevent lateral movement on piers.

Table 65. Maximum lengths of two adjacent spans of a continuous bridge that can be jacked over intermediate pier with Jacks Arranged as in Figure 214(1)[1]

Construction of spans	Two jacks under trusses at each side of bridge[2]				Four jacks under trusses at each side of bridge[3]				
SS:									
Short span	0–35	40	45–55		0–55	60–100			
Long span	[4]	60[5]	55[5]		[4]	100			
DS:									
Short span	0–55	60–70	75–90		0–80	85–140			
Long span	[4]	95[5]	90[5]		[4]	140			
TS:									
Short span	0–65	70–80	85–95	100–105	0–95	100–160			
Long span	[4]	115	110	105	[4]	160			
DD:									
Short span	0–50	55–70	75–80		0–105	110–180			
Long span	[4]	85	80		[4]	180			
TD:									
Short span	0–40	45–55	60–65		0–95	100	105–120	125–135	140–145
Long span	[4]	70	65		[4]	160	155	150	145
DT:									
Short span	0–35	40–50	55–65		0–75	80–100	105–115	120	
Long span	[4]	65	60		[4]	130	125	120	
TT:									
Short span	0–30	35–45	47.5		0–60	65–75	80–90	95	
Long span	[4]	50	47.5		[4]	105	100	95	

[1] Based on dead weight of two spans over intermediate pier.

[2] Strength of jacks (15 tons) limits this jacking arrangement to a capacity of 56 tons except as noted in footnote 5. Truss spacing causes eccentric load on jacking beam.

[3] Strength of jacks limits this jacking arrangement to a capacity of 111 tons.

[4] As length of short span decreases, long span is limited by rule that short span must be at least 60 percent of length of long span.

[5] Based on 10-ton maximum concentrated load on panel chord between panel support points.

Table 66. Maximum lengths of two adjacent spans of a continuous bridge that can be jacked over intermediate Pier with Jacks Arranged as in Figure 214(2)[1]

Construction of spans	Six jacks under trusses at each side of bridge[2]				Twelve jacks under trusses at each side of bridge[3]				
SS:									
Short span	0–55	60–100			0–55	60–100			
Long span	[4]	100			[4]	100			
DS:									
Short span	0–80	85–140			0–80	85–140			
Long span	[4]	140			[4]	140			
TS:									
Short span	0–95	100–160			0–95	100–160			
Long span	[4]	160			[4]	160			
DD:									
Short span	0–85	90–110	115–125	130–140	0–105	110–180			
Long span	[4]	150	145	140	[4]	180			
TD:									
Short span	0–65	70	75–85	90–100	0–115	120–200			
Long span	[4]	110	105	100	[4]	200			
DT:									
Short span	0–55	60–65	70–80	85–90	0–125	130–135	190–195	200	
Long span	[4]	100	95	90	[4]	210	205	200	
TT:									
Short span	0–45	50–55	60–70	72.5	0–95	100–110	115–125	130–140	145
Long span	[4]	80	75	72.5	[4]	160	155	150	145

[1] Based on dead weight of two spans over intermediate pier.

[2] Strength of jacks limits this jacking arrangement to a capacity of 84 tons. Strength of jack is 7.5 tons on toe. Truss spacing causes eccentric load on jacking beam.

[3] Strength of jacks limits this jacking arrangement to a capacity of 168 tons. Two ramps per side of bridge are required.

[4] As length of short span decreases, long span is limited by rule that short span must be at least 60 percent of length of long span.

CHAPTER 25

PANEL CRIB PIERS AND TOWERS

220. Scope

This chapter describes the construction of panel crib piers built with equipment of the fixed panel bridge, Bailey type.

221. Use

Panel crib piers are used as—

a. Intermediate supports for through- and deck-type fixed bridges. The piers can be set on timber grillage, piles (fig. 215), masonry footings (fig. 216), or partially demolished piers (fig. 195).

b. Piers in barge bridges.

c. Intermediate landing-bay piers in floating panel bridges with double landing bays.

d. Expedient towers for suspension bridges, lift bridges, gantries, and floating-bridge anchor cables (fig. 217).

e. Expedient marine piers.

222. Design

a. COMPOSITION. Panel crib piers are made of trusses with panels set horizontally or vertically and are normally braced with transoms, sway bracing, rakers, bracing frames, and tie plates as in a panel bridge.

b. TYPES OF CRIB. (1) *Nomenclature.* Panel crib piers are described by—

(*a*) Number of *trusses* (single, double, triple, and so on, as in a panel bridge).

(*b*) Number of *stories* (number of panels along the vertical axis in one bay as in the panel bridge).

(*c*) Number of *bays* (number of panels along the horizontal axis in a given story).

(*d*) *Position* of panels in each story (horizontal or vertical).

(2) *Abbreviations.* Table 67 lists the abbreviations used to describe typical panel crib piers.

(3) *Number of trusses.* Panel cribs have from one to four trusses on each side depending on the desired capacity. There must always be at least as many trusses in the crib as in the bridge it supports.



Figure 215. Two continuous panel bridges with panel crib piers on pile piers. A 410-foot bridge of this type was constructed over the Arno River at Florence, Italy, by Fifth Army Engineers. See figures 260, 261, 264, and 265 for other views of this bridge.

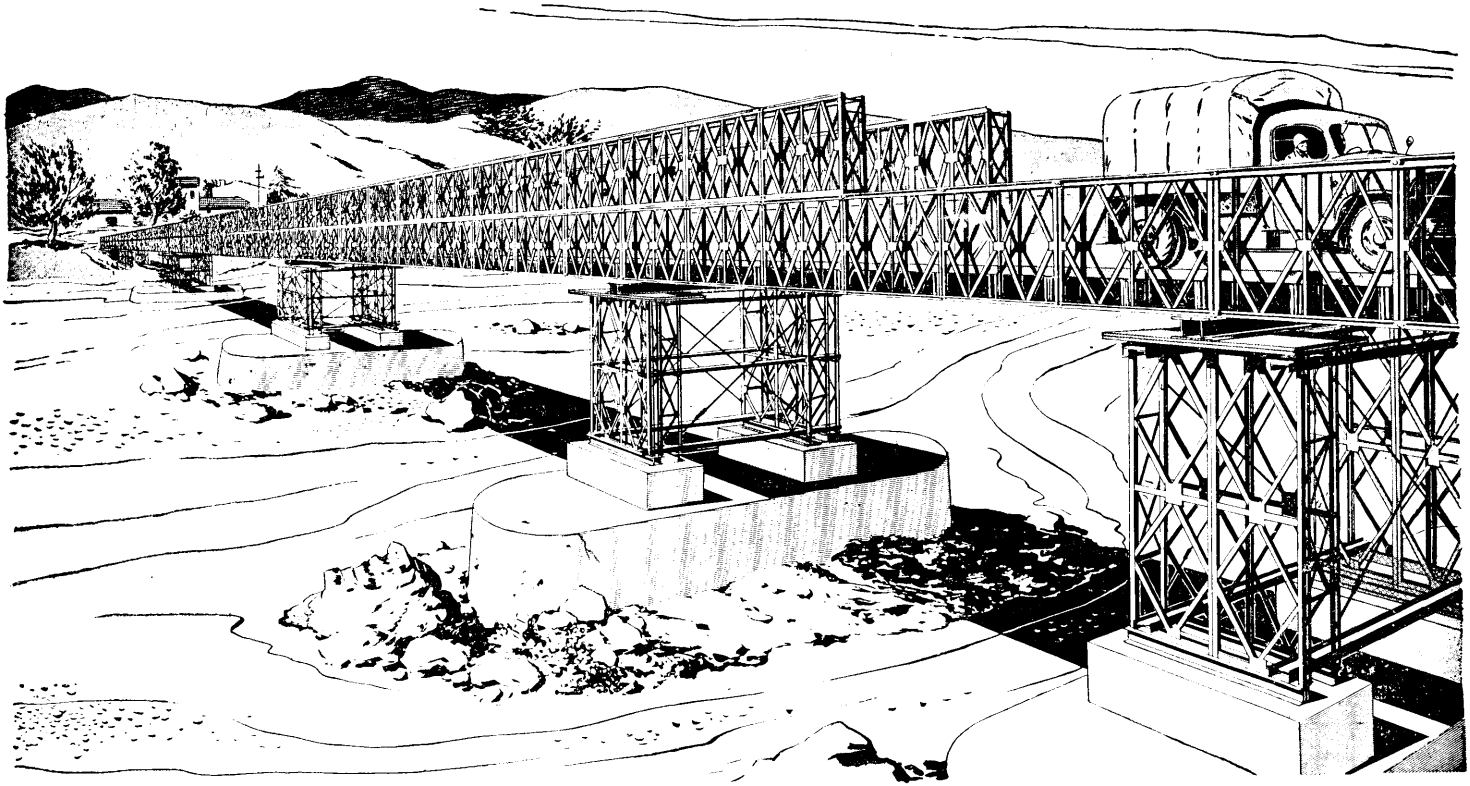
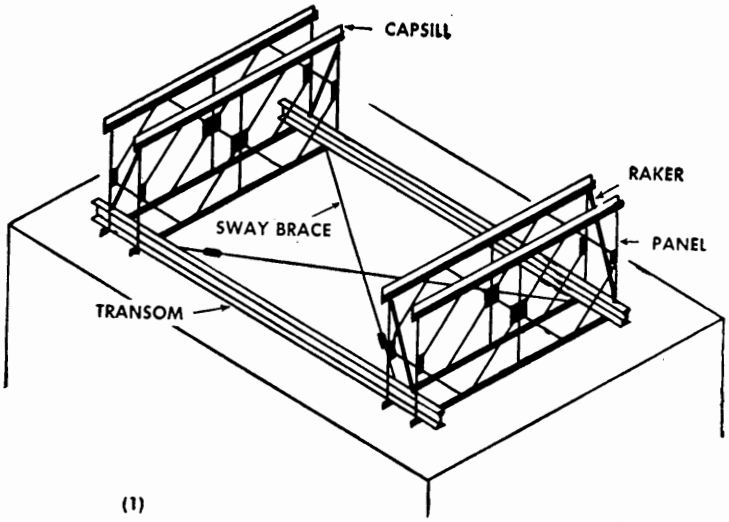
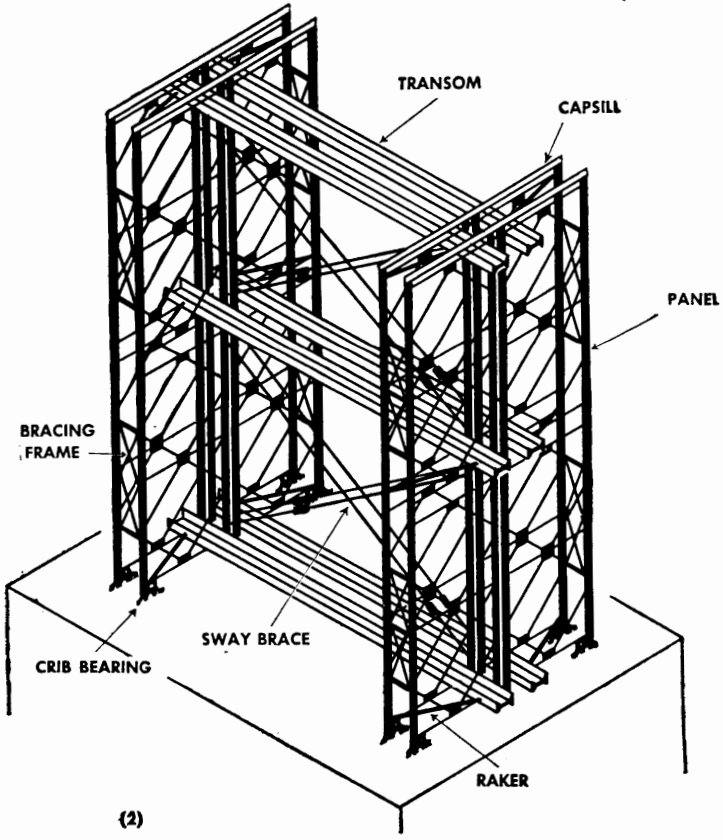


Figure 216. Continuous panel bridge with panel crib piers on concrete footings. A 530-foot bridge of this type was constructed over the Volturno River at Ponte di Naviscantina, Italy, by Fifth Army Engineers. See figure 213 for another view of this bridge.

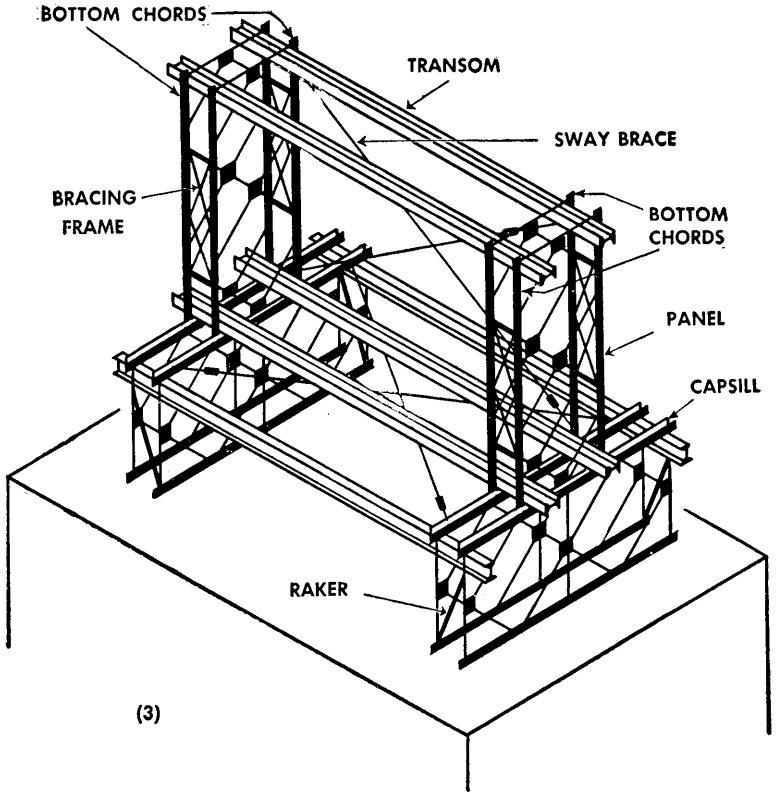


①*DS(1H) panel crib pier with panels horizontal*



②*DD(2V–2V) panel crib pier with panels vertical*

Figure 218. Panel crib pier.



③*DD (1H–IV) panel crib pier with panels both horizontal and vertical*

Figure 218. Panel crib pier—Continued.

on junction links, or one or two I-beams at right angles to the bridge axis. With this type of bridge seating, bottom chords of the bridge over the seating are normally reinforced by a steel beam to distribute the load and prevent failure of the panel chords due to local bending. These rockers are described and illustrated in chapter 24.

(*b*) *Rocker at base of crib.* If the crib is fastened rigidly to the bridge, it must rock with the bridge as the girders deflect under load. A rocker at the base of the crib can be built of crib bearings on standard bearings ((1), fig. 230) or inverted junction-link bearings on junction links ((2), fig. 230).

(*c*) *No rocker.* As an expedient when rocking bearings cannot be improvised, the bridge can be seated on timber on top of the piers (fig. 248), or the pier itself can be bedded on timber, which is elastic enough to allow for rocking.

(2) *Broken-span bridge.* (*a*) *Standard.* In broken-span construction, the adjacent ends of the two spans are seated on the junction-link bearings by use of span junction posts and junction links (fig. 219).

(4) *Number and position of panels.* Panels in a panel crib pier are horizontal (fig. 218①), vertical (fig. 218②), or both (fig. 218③).

(*a*) Horizontal panels provide a 5-foot increment in pier height. They are, however, weak laterally and are used one above the other only when expedient bracing is added (par. 227 and figs. 256 and 257).

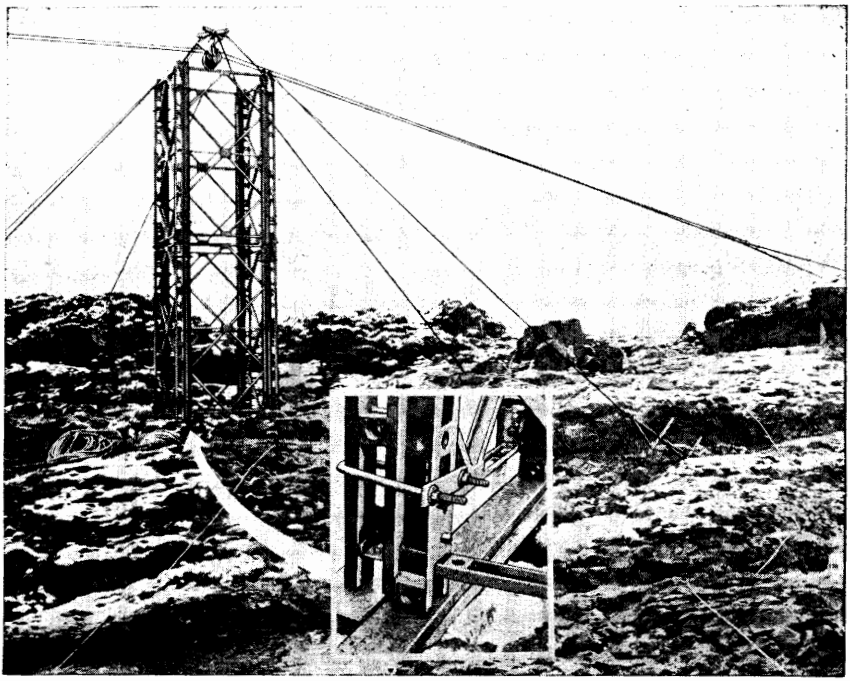


Figure 217. Expedient panel crib anchor-cable tower for a floating bridge. U-bolts are used at each corner as indicated in the inset.

(*b*) Vertical panels provide 10-foot increments in pier height. They can be used one above the other in piers up to 70 feet high. In high piers, more bays are generally added to the base to give greater stability (figs. 237 and 251).

(*c*) To construct 15-, 25-, 35-, 45-, 55-, and 65-foot piers, vertical stories are used with only one 5-foot horizontal story placed either at the top or bottom of the crib.

c. Types of Bridge Seating. (1) *Continuous bridge.* Deflection of a span under load tends to change the slope of the bridge at the piers. To prevent large stresses in the bridge and pier, some rocking movement must be allowed at intermediate supports of continuous bridges.

(*a*) *Rocker at top of crib.* A rocker at top of the crib can be built of crib bearings on standard bearings, inverted junction link bearings

(*b*) *Expedient.* As an expedient, the adjacent ends of the two spans can be pinned to the vertical panels in the pier as in figure 249; or the two ends can rest on separate bearings as in figure 257.

223. Description of Special Parts

Special parts for panel crib piers are as follows:

Part	*Weight (lb)*	*Figure reference*
Female span junction post	202	220
Male span junction post	194	220
Junction chess	86	221
Junction link	36	222(1)
Junction-link bearing	217	223
Chord clamp	11	222(2)
Crib capsill	251	225
Crib bearing	37	228(1)

Figures 219 to 229 illustrate uses of the special parts.

a. SPAN JUNCTION POSTS (fig. 220). (1) *Use.* Span junction posts are special end posts for connecting adjacent ends of two spans and supporting them on the same bearing.

(2) *Description.* (*a*) There are two types of junction posts, male and female, which have lugs that are pinned to female and male ends, respectively, of standard panels. At the junction, each post has two other connecting lugs, a male or female lug at the top according to type, and a universal jaw at the base. Irrespective of type, two posts can be connected at the base by a normal panel pin. A safety pin *must* always be used on the panel pin at this joint. An intermediate pin hole and recess in the base of each post is for the junction link.

(*b*) During launching, the top lugs of the posts are connected by a launching link Mk II. The launching link Mk II will only fit between one female span junction post and one male span junction post, and care must be taken when constructing the two spans to keep *all* the male lugs on the panels faced the same way. After the bridge is jacked down and posts are pinned to the junction link, the launching link Mk II and the pin joining the two posts at their base are removed. Then the gap between the top lugs of the posts allows an upward slope of 6.7 to 1 or a downward slope of 5 to 1 in one span when the other is level. The female span junction post weighs 202 pounds, and the male span junction post weighs 194 pounds.

b. JUNCTION CHESS (fig. 221). (1) *Use.* Junction chess span the gap in the bridge floor between the ends of two spans connected by span junction posts. Four-junction chess are used at each span junction.

(2) *Description.* The junction chess consists of two 6-foot 10½-inch timbers fastened to nine steel I-beams 11½ inches long. The junction chess weighs 149 pounds.

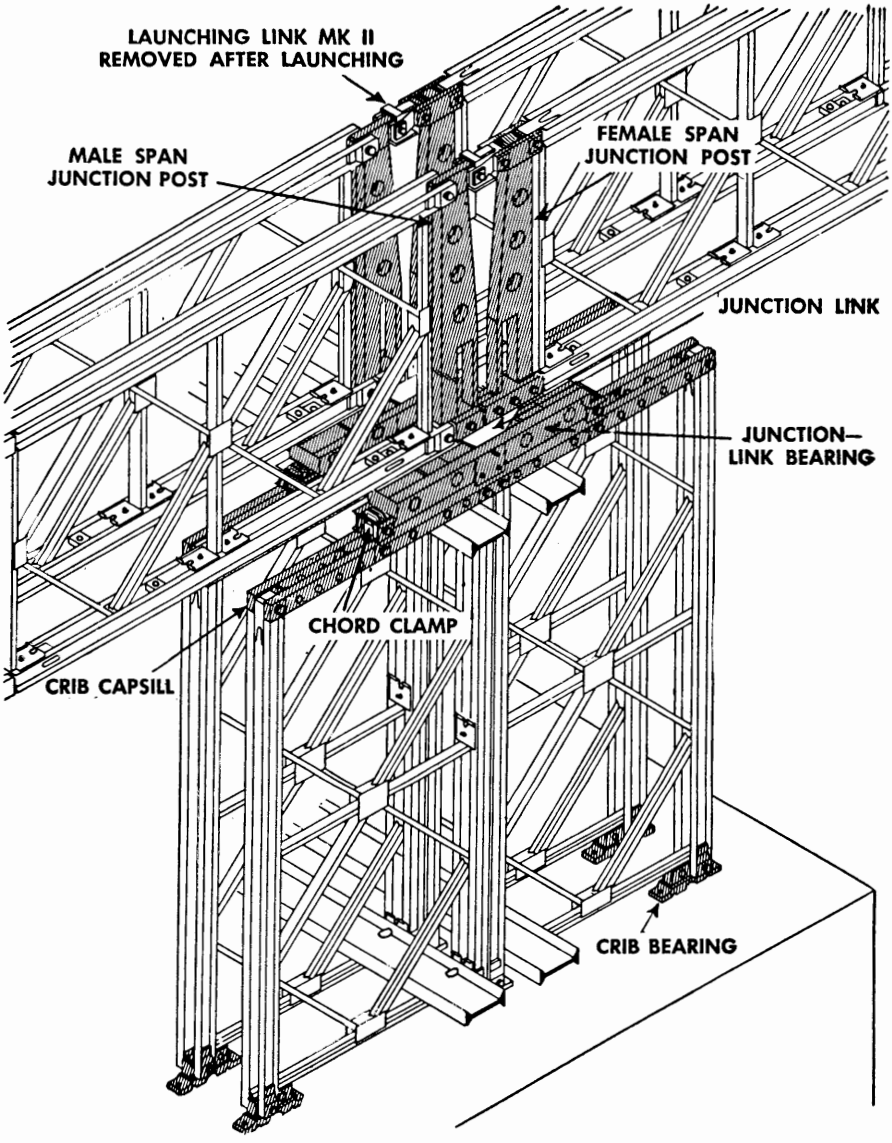


Figure 219. Construction of typical panel crib pier showing use of special panel crib parts.

c. Junction Link (fig. 222①). (1) *Use.* The junction link transfers the end reaction from two span junction posts to a junction-link bearing.

(2) *Description.* The junction link is a triangular-shaped steel assembly with two projecting male lugs on its top side spaced to pin with panel pins to the two span junction posts. Both holes are elongated to permit some play in the joint. A safety pin must always be used on

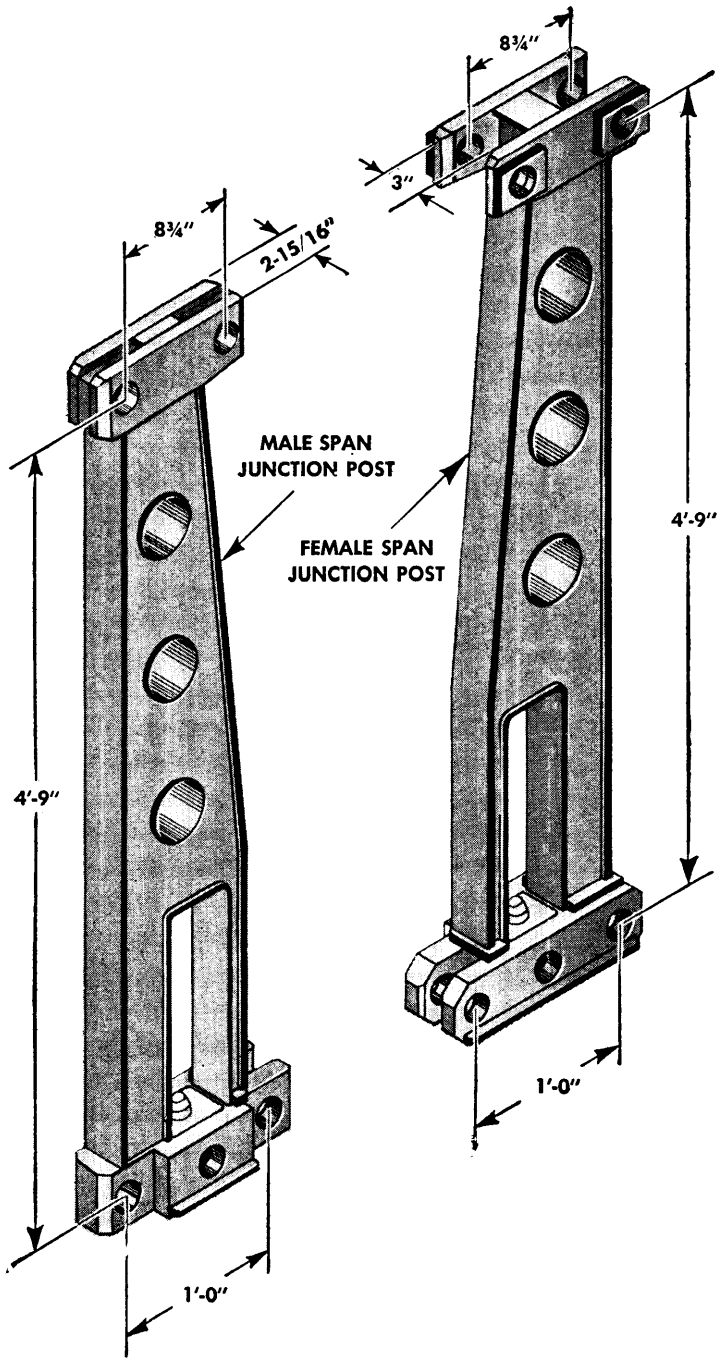


Figure 220. Span junction posts.

the panel pins at this joint. The bottom of the junction link tapers down to a nose with a tubular bearing which seats in the curved bearing plate of the junction-link bearing and is held in place by a captive pin on the junction-link bearing. The junction link weighs 36 pounds.

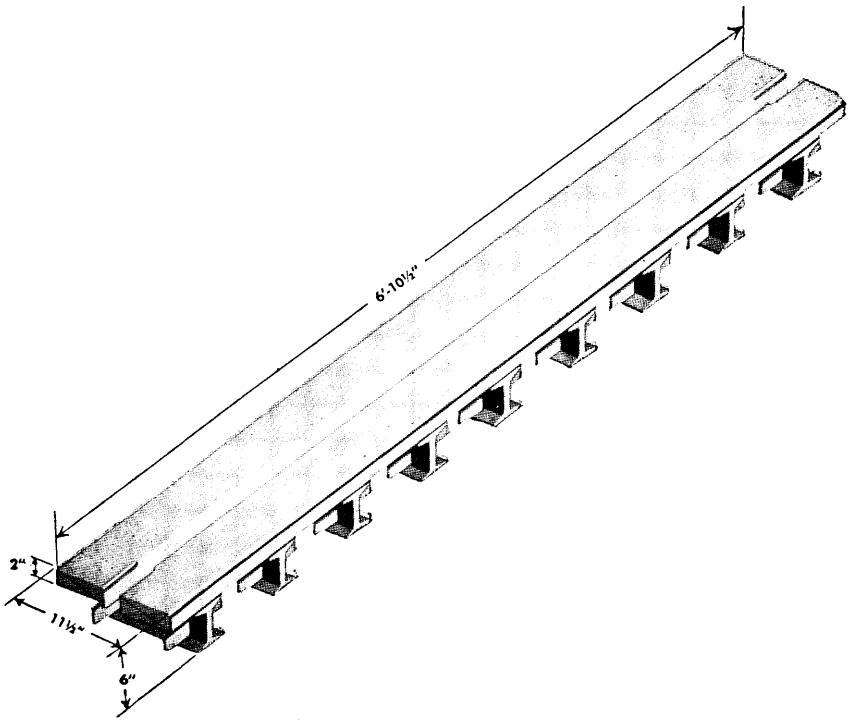


Figure 221. M2 junction chess.

d. JUNCTION-LINK BEARING (fig. 223). (1) *Use.* The junction link bearing is used under the junction link which supports the ends of the bridge. It can be used in the following way:

(*a*) *Supported by a vertical panel.* If male lugs of the panel are uppermost, jaws of the junction-link bearing are pinned to the panel lugs (fig. 224). If female lugs are uppermost, the jaws of the junction-link bearing rest on top of the lugs and are fastened by chord clamps (fig. 233).

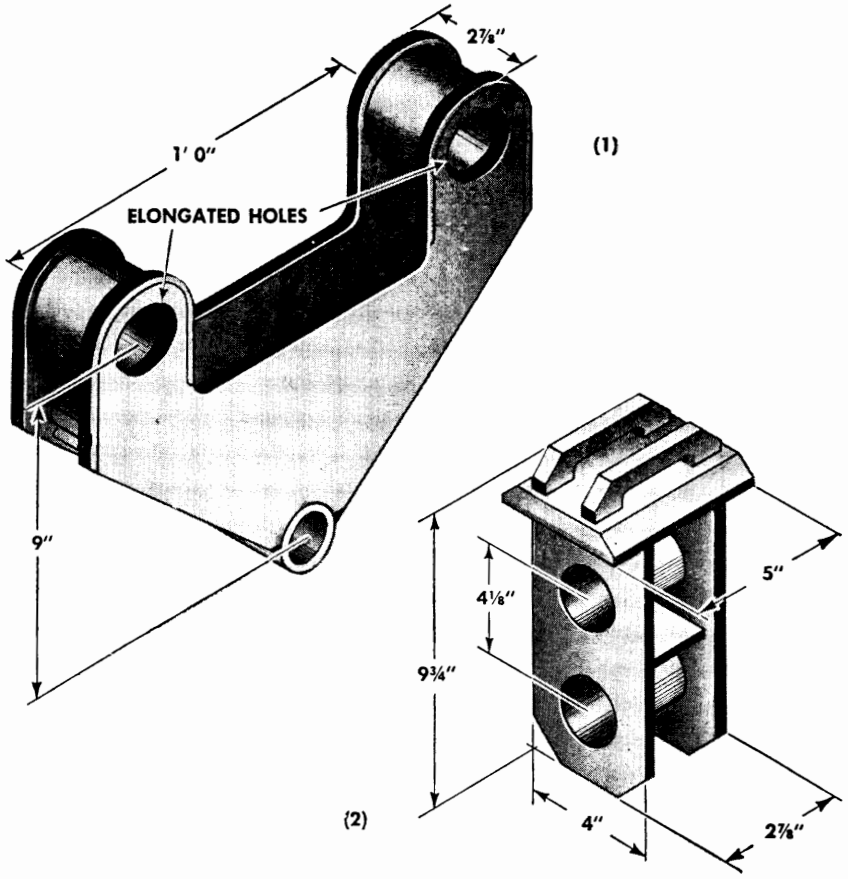
(*b*) *Supported by crib capsill* (fig. 219). Chord clamps secure junction-link bearing to crib capsill.

(*c*) *Supported by crib capsill* (fig. 229③). Crib bearing is pinned to two center holes of junction-link bearing with panel pins.

(*d*) *Used under female end of vertical panel* (fig. 229 ③). Female lugs of panel rest on jaws of junction-link bearing and are secured by chord clamps.

(*c*) *Supported by timber.* Junction-link bearing is laid directly on a timber support.

(2) *Description.* The junction-link bearing is made of two 8-inch channels welded back to back with the same spacing as between channels in the chords of the panel. It is 5 feet 1 inch long and has female jaws at each end. The distance between panel-pin holes in the female jaws is 4 feet 9 inches, the same as vertical distance between pin holes in the panel. Between the webs of the channels in the center of the junction-link bearing is a curved bearing plate on which the junction link bears. There is a hole through the webs of the channels just above the curved bearing plate for a captive pin which locks the junction link in place. There are two panel-pin holes in the webs of the channels beneath the curved bearing plate. They are used to pin the crib bearing which fits in the recess between the channels. A junction-link bearing weighs 217 pounds.



①*Junction link.* ②*Chord clamp.*

Figure 222.

e. CHORD CLAMP. (fig. 222 ②). (1) *Use.* The chord clamp is used to pin—

(*a*) Crib capsill to panel chord (fig. 227).

(*b*) Crib capsill to female jaw of panel.

(*c*) Crib capsill to junction-link bearing (fig. 219).

(*d*) Junction-link bearing to female jaw of panel.

(2) *Description.* The chord clamp is in effect a double-length male lug with two panel-pin holes and a T-head. The clamp is slipped between the chord channels of a panel until the head bears on the channel flanges, then the clamp is pinned to a crib capsill or other female joint with a panel pin. If the chord clamp is slipped through two adjacent female jaws, it is pinned to each by panel pins through both holes in the chord clamp. The chord clamp weighs 11 pounds.

f. CRIB CAPSILL (fig. 225). (1) *Use.* The crib capsill distributes the load from the bridge to the main chords of *vertical* panels or to the three verticals of *horizontal* panels in a crib. It has unreinforced panel-pin holes used only to pin chord clamps (fig. 227), and reinforced holes used to take the vertical load. The reinforced holes are used to pin the capsill to the following:

(*a*) Male lugs of single vertical panels (fig. 226).

(*b*) Male lugs of two adjacent vertical panels (fig. 226).

(*c*) Crib bearing (fig. 229 ②).

(2) *Description.* The crib capsill is made of two 4-inch channels welded back to back to spacer lugs with the same spacing between chan-

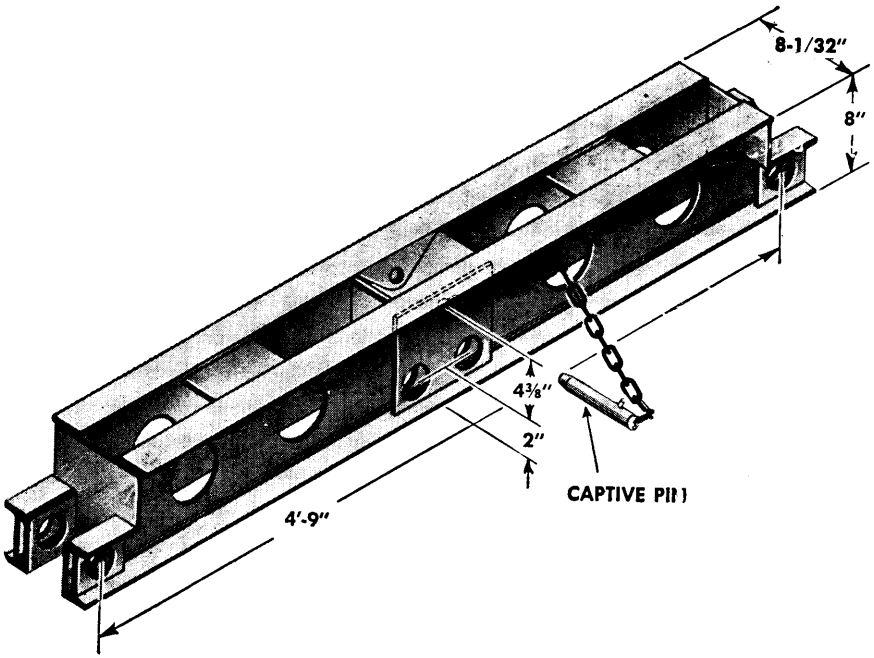


Figure 223. Junction-link bearings.

nels as in the chord of the standard panel. It is 10 feet 2 inches long, and has female jaws at each end. Holes are spaced along the webs of the channels. Six pairs of panel-pin holes are reinforced with steel blocks and spaced so male lugs of two adjacent panels or of a single panel can be connected to the crib capsill with panel pins. Additional unreinforced holes for chord clamps are spaced generally at 6-inch centers between the reinforced holes. The crib capsill weighs 251 pounds.

g. CRIB BEARING (fig. 228①). (1) *Use.* The crib bearing is used as a base for panel cribs and can be pinned with panel pin to the following:

(*a*) One female jaw of a vertical panel (fig. 229①).

(*b*) Two female jaws of adjacent vertical panels (fig. 229①).

(*c*) Two central holes of a crib capsill (fig. 229②).

(*d*) Two central holes of a junction-link bearing (fig. 229③).

The crib bearing can be spiked to a timber sill (fig. 228②) to provide a rigid base, or set on a standard bearing (fig. 228③) to provide a rocker bearing.

(2) *Description.* The crib bearing is in effect a double-length male lug welded horizontally to a base block. One of the pin holes is elongated to make pinning easier when both holes are used. If only one hole is needed, the circular one is used. Holes are provided in the base block of the crib bearing for spiking to a timber sill. The underside of the base block has a semicircular bearing to seat on a standard bearing. The crib bearing weighs 37 pounds.

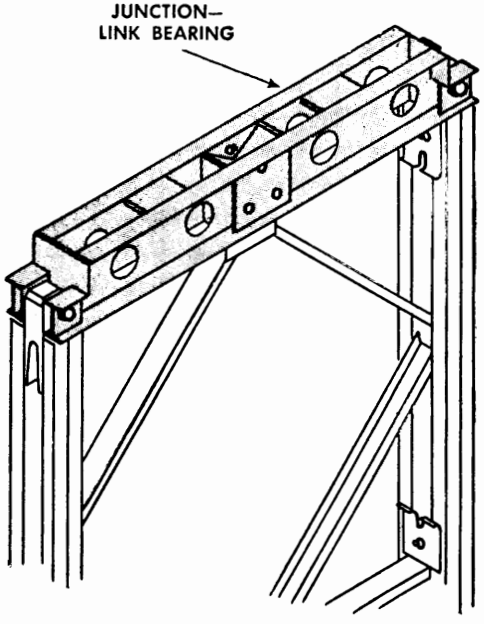


Figure 224. Use of junction-link bearing on male lugs of vertical ***panel.***

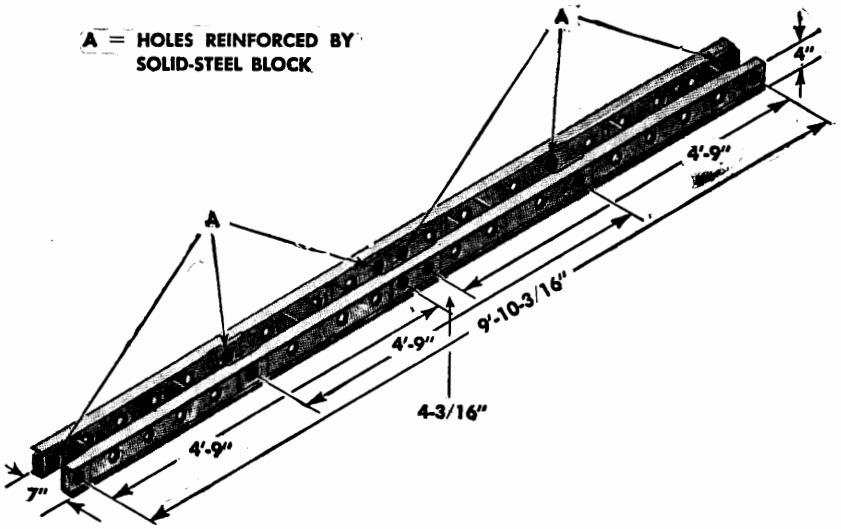


Figure 225. Crib capsill.

224. Capacity

a. Load on Crib. Paragraph 208*c* (2) describes a method for determining the approximate load transmitted to the crib by the ends of two *independent* spans. *Continuous-span* construction over the pier transmits greater load to the pier. These reactions are listed in table 64.

b. Capacity of Crib. (1) *Standard construction.* (*a*) *With special panel crib parts.* Figures 230 to 237 illustrate standard construction of piers built with special panel crib parts. Capacities are given in all cases. Single-truss cribs can take 50 percent of the loads given for double-truss cribs with only the inner truss loaded. Single-truss cribs can be used only for light loads on low cribs. The capacity of panel crib piers is usually limited by strength of the junction link, junction-link bearing, and crib capsill (table 68). Improvised panel crib parts can be used in place of the special parts without reducing the capacity of the pier if the improvised parts are as strong as the part they replace.

(*b*) *Without special parts.* If special panel crib parts are not used, the load is carried by the top members of vertical panels in the crib. Timber is laid on top members of each panel so the load is concentrated at three points—at the center, and near each end adjacent to the panel chords. With the load applied in this manner, the top member of one vertical panel will carry about 14 tons, and piers with this type of bearing will have the same capacity as piers of corresponding construction built with special parts.

(2) *Expedient construction.* Pier capacity varies with type of construction, distribution of load, and strength of individual parts. All these factors must be considered when estimating the capacity of expedient panel cribs.

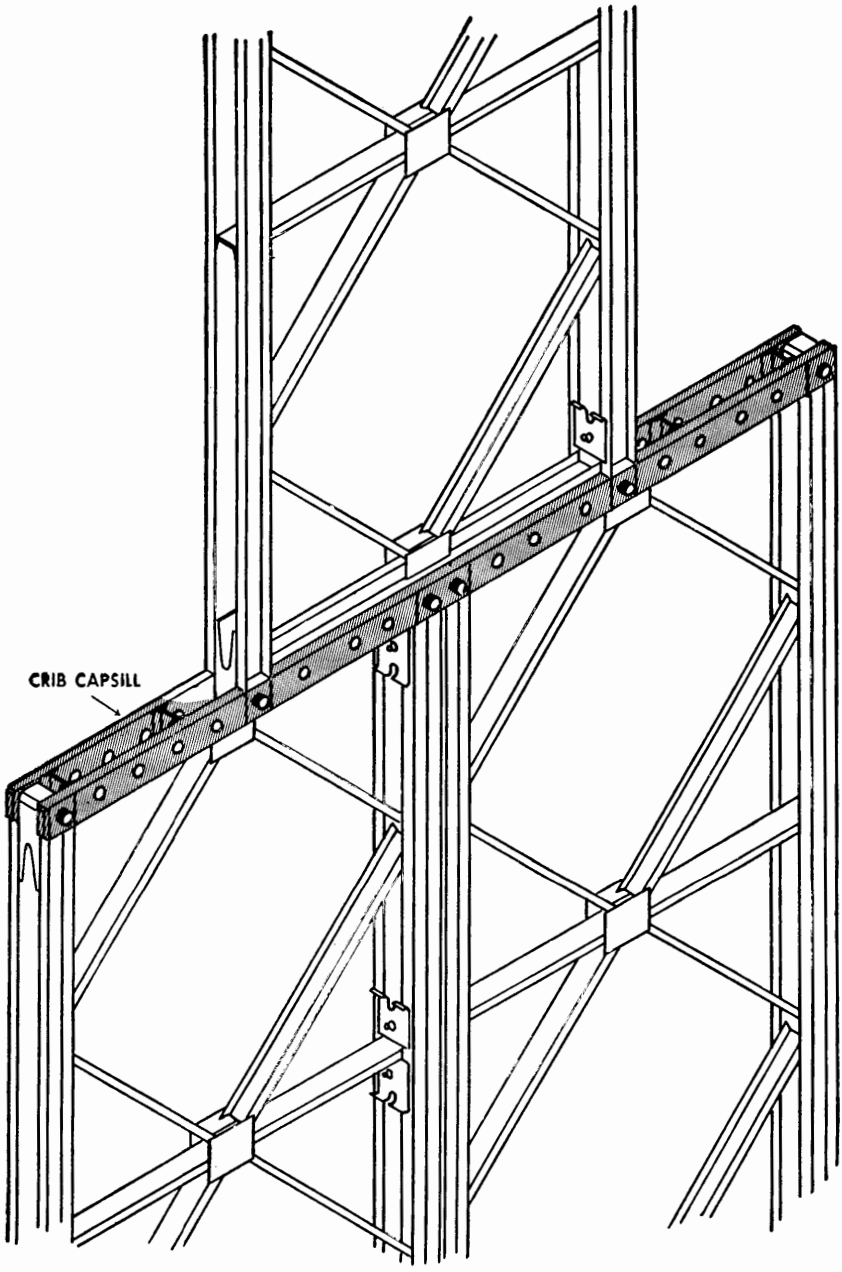


Figure 226. Use of crib capsill to connect a single vertical panel to two vertical panels. Male lugs of panels fit into crib capsill and are pinned to reinforced holes of capsill.

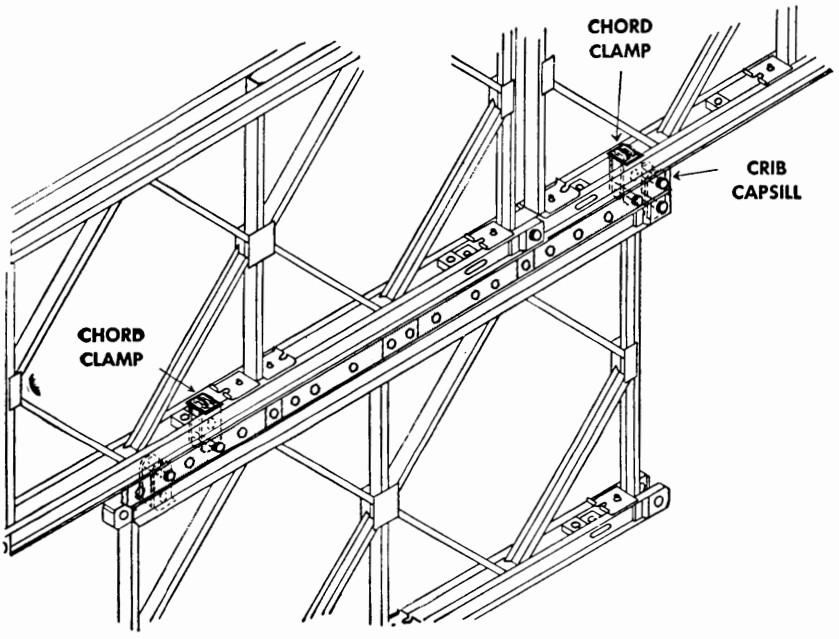
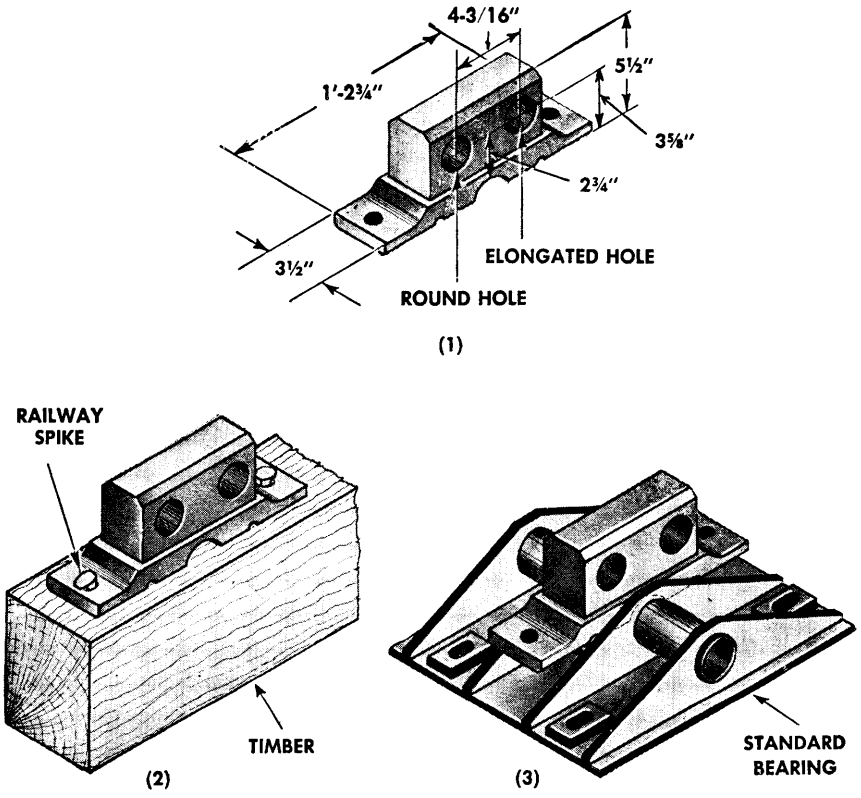


Figure 227. Use of crib capsill and chord clamps to connect horizontal panels of bridge and pier. Chord clamps are pinned to any of the holes in the capsill.

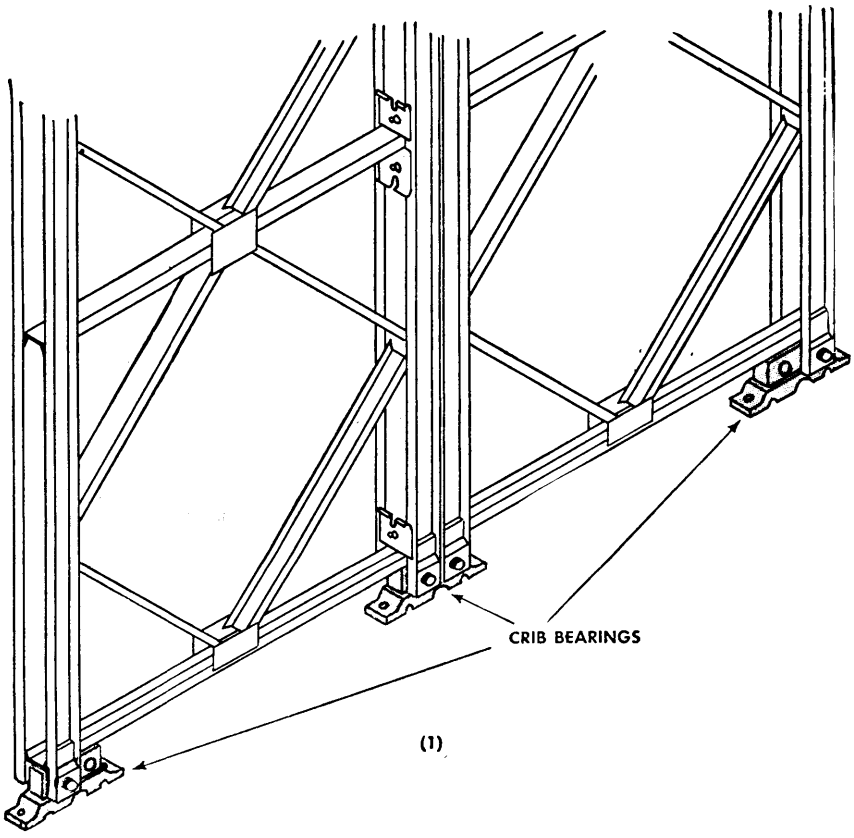


①*Crib bearing.*

②*Crib bearing spiked to timber sill to provide fixed bearing.*

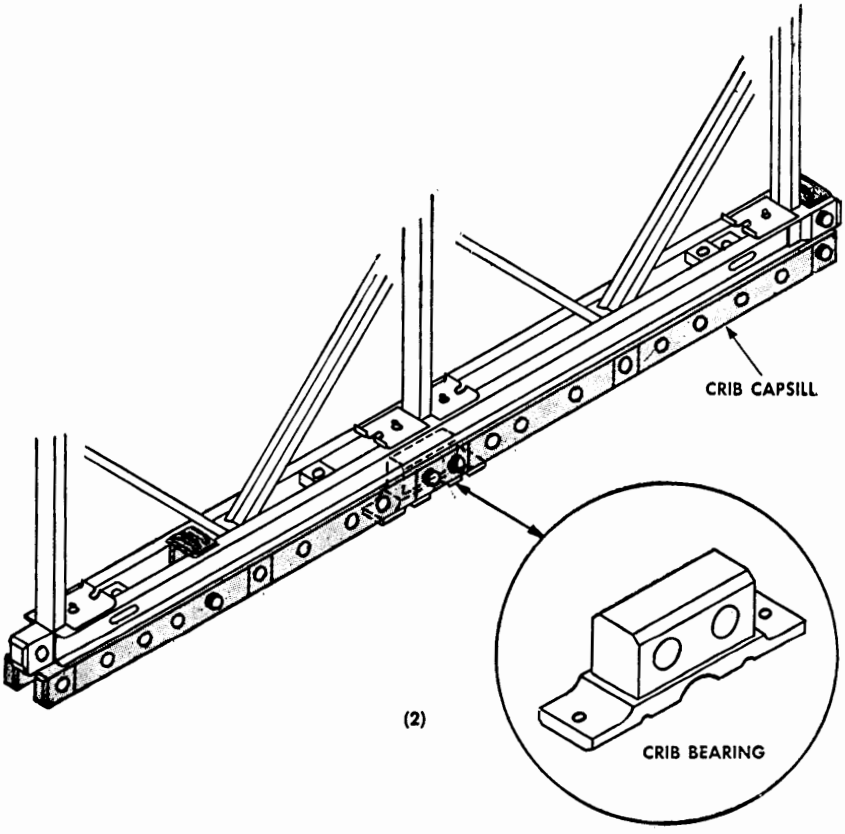
③*Crib bearing used with standard bearing to provide rocker bearing.*

Figure 228. Crib bearing.



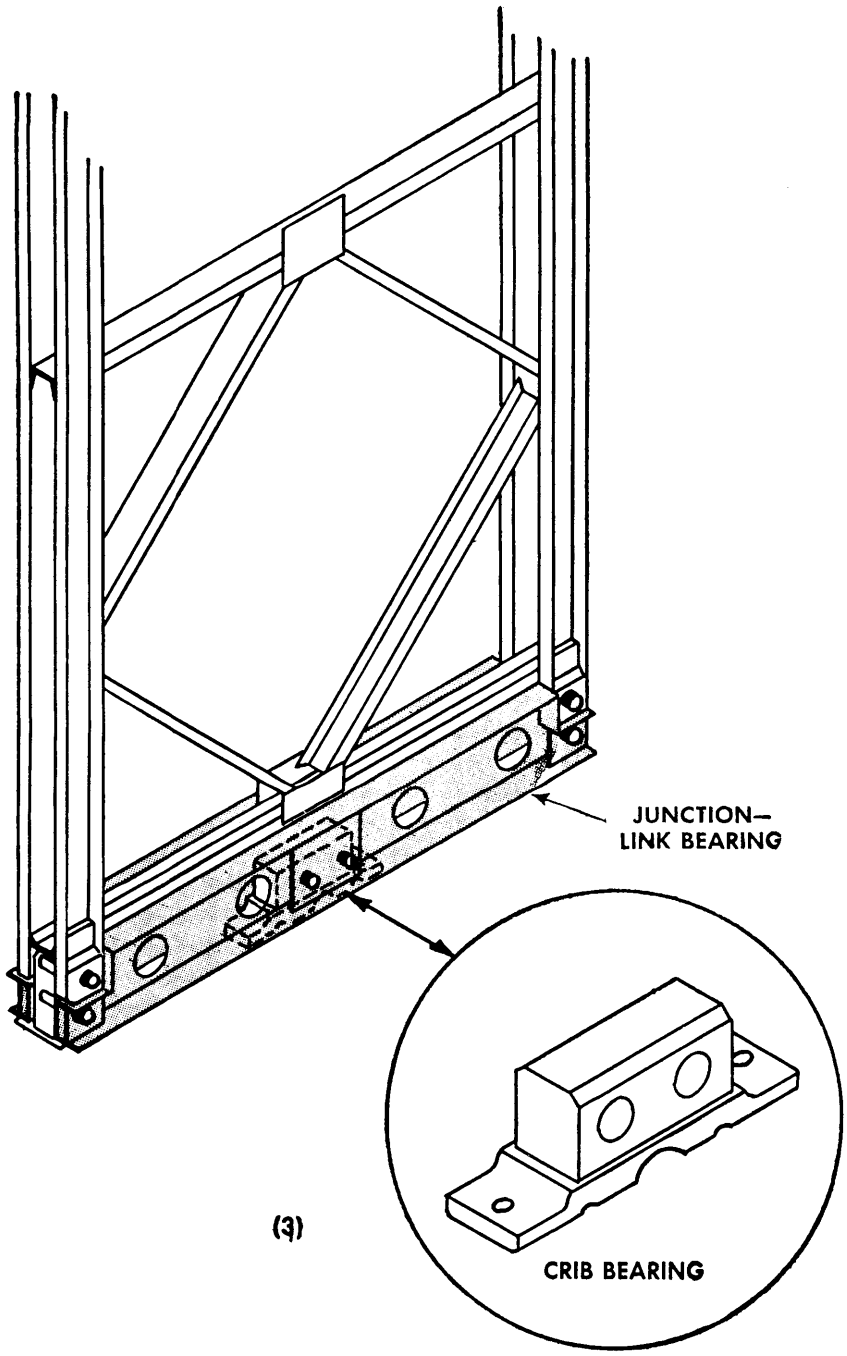
(1)*Crib bearings pinned to one and to two adjacent female jaws of vertical panels.*

Figure 229. Crib bearings.



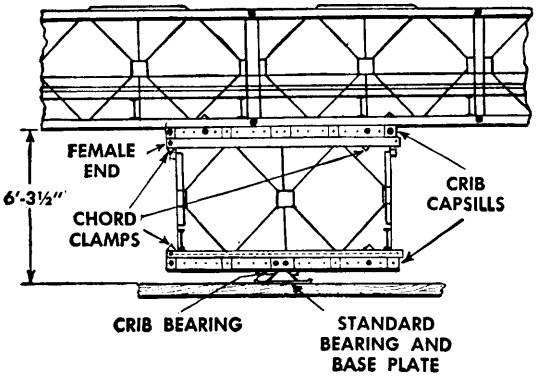
②*Crib bearing under crib capsill.*

Figure 229. Crib bearings—Continued.



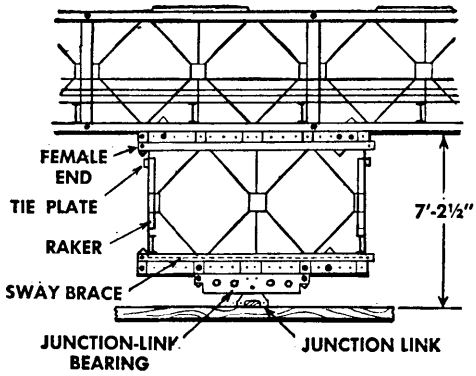
③*Crib bearing under junction-link bearing.*

Figure 229. Crib bearings—Continued.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	35
All trusses loaded	70
Triple truss	90

(1)



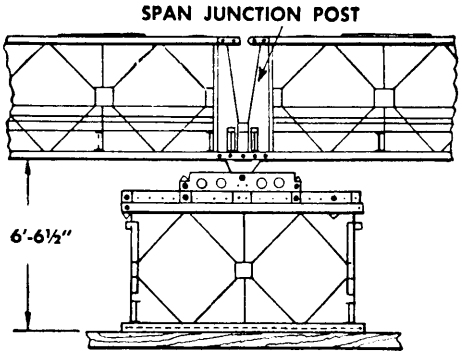
Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	50
All trusses loaded	100
Triple truss	145

(2)

①*Using standard bearings.*

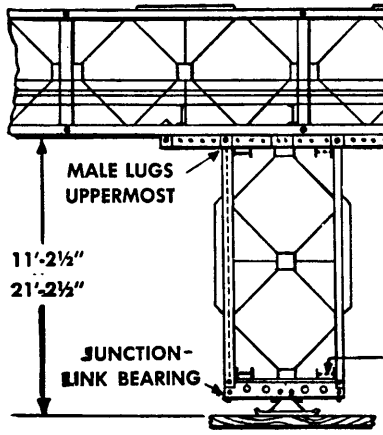
②*Using junction-link bearings.*

Figure 230. Single-story single-bay crib with panels horizontal. Continuous bridge with rocker bearing at base of crib.



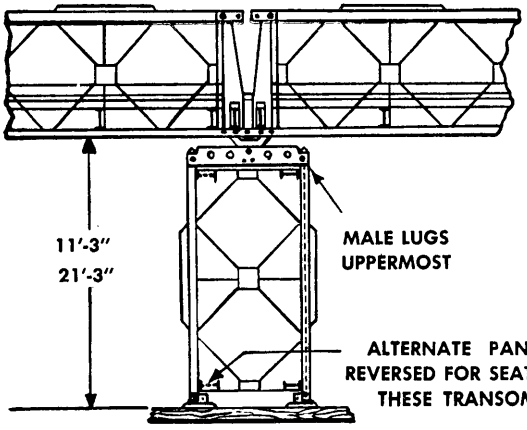
Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	50
All trusses loaded	100
Triple truss	145

Figure 231. Single-story single-bay crib with panels horizontal. Bridge broken over crib.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	30
All trusses loaded	60
Triple truss	80

(1)

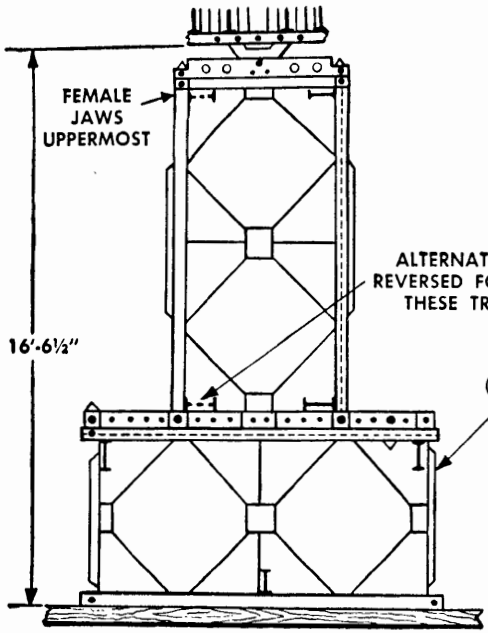


Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	30
All trusses loaded	60
Triple truss	80

(2)

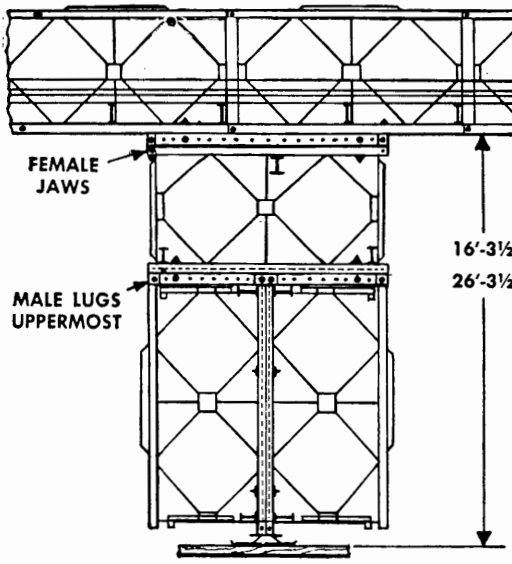
①*Continuous bridge with rocker bearing at base of crib.*
②*Bridge broken over crib.*

Figure 232. Single- to double-story single-bay crib with panels vertical.



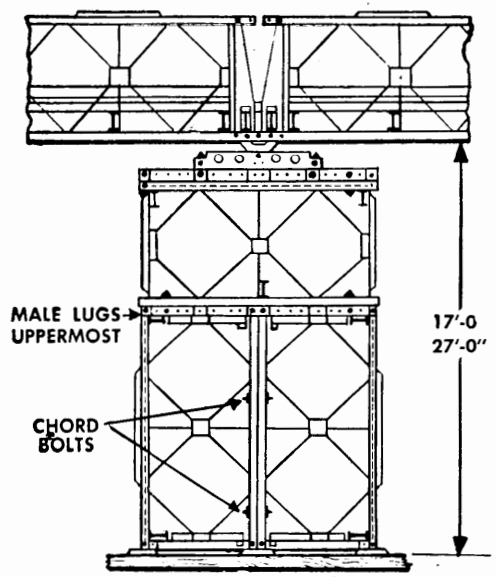
Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	30
All trusses loaded	60
Triple truss	80

Figure 233. Double-story single-bay crib with panels both horizontal and vertical. Bridge broken over crib.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	50
All trusses loaded	100
Triple truss	145

(1)



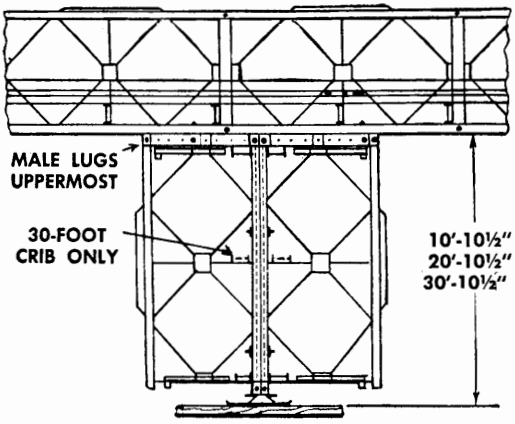
Capacity of crib (short tons)	
Double truss: Inner truss only loaded	50
All trusses loaded	100
Triple truss	145

(2)

①*Continuous bridge with rocker bearing at base of crib.*

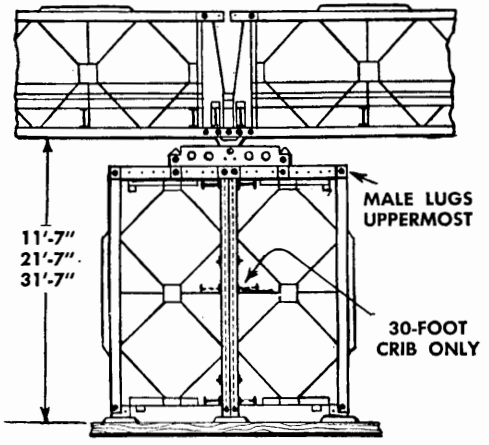
②*Bridge broken over crib.*

Figure 234. Double- to triple-story double-bay crib with panels both horizontal and vertical. Double bay of vertical panels in bottom stories.



(1)

Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	45
All trusses loaded	90
Triple truss	130

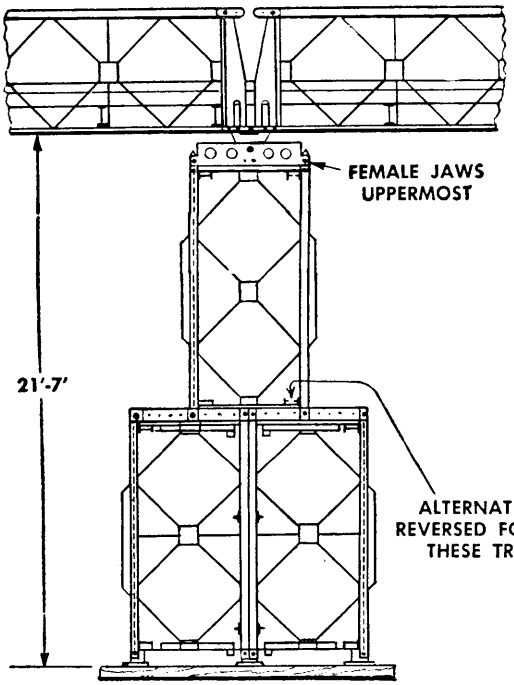


(2)

Capacity of crib (short tons)	
Double truss: Inner truss only loaded	50
All trusses loaded	100
Triple truss	145

①*Continuous bridge with rocker bearing at base of crib.*
②*Bridge broken over crib.*

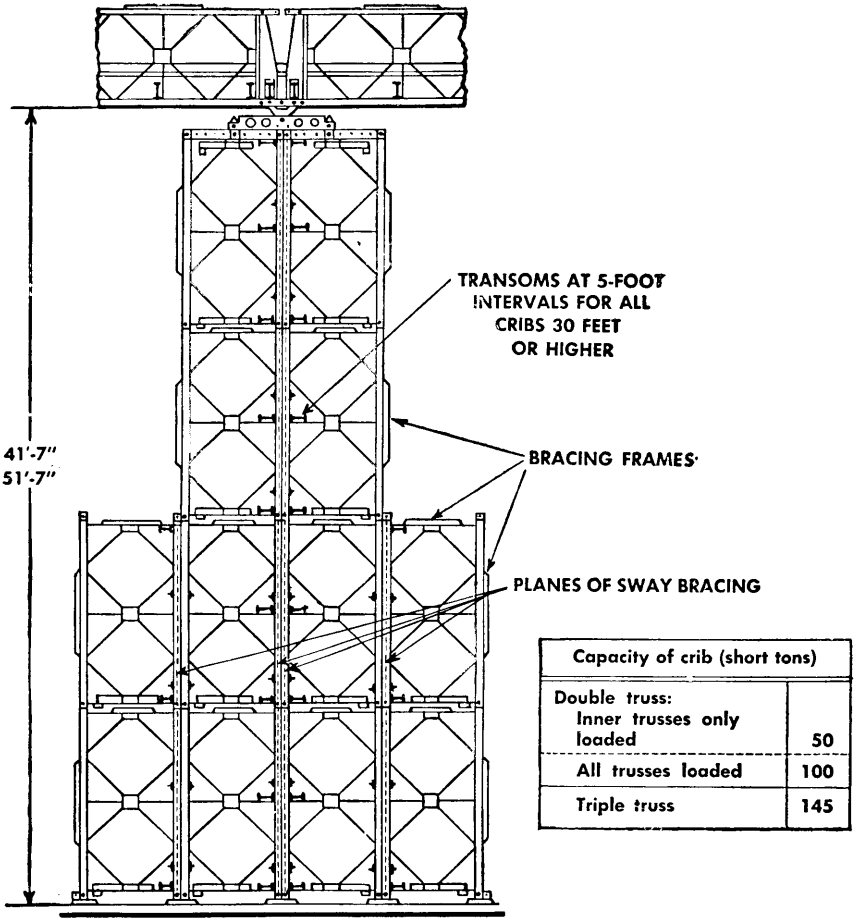
Figure 235. Single- to triple-story double-bay crib with panels vertical.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	30
All trusses loaded	60
Triple truss	80

NOTE: THIS CONSTRUCTION IS NOT TO BE USED INVERTED

Figure 236. Double-story crib with panels vertical. Two bays in first story and one in second story. Bridge broken over crib.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	50
All trusses loaded	100
Triple truss	145

Figure 237. Four- to five-story crib with panels vertical. Four bays in two bottom stories and two bays in upper stories. Bridge broken over crib.

c. STRENGTH OF PARTS. Table 68 gives the strength of the individual panel crib parts for use in estimating the capacity of expedient panel cribs.

225. Bills of Material

a. Table 69 lists the number of parts required to build the standard crib piers illustrated in figures 230 to 237, and number unit truck loads required to supply these parts.

b. Panel bridge conversion set No. 3, panel crib pier, supplies the special panel crib parts to build a 31 foot 7 inch TT (2V–2V–2V) pier with the addition of standard panel bridge parts. The parts in conversion set No. 3 are listed in chapter 6.

c. The conversion set No. 3 makes two crib-pier loads each carried by a 2½-ton cargo truck. These truck loads are described in chapter 6. The number of crib pier loads and standard unit truck loads required to build each pier is given in table 69.

226. Standard Construction

a. TRUSSES. The trusses in standard panel crib piers are parallel to trusses in the bridge. The crib must have at least the same number of trusses as the bridge it is to carry. More trusses can be added for increased strength (figs. 238, 239, and 240). Single-truss construction can be used only for low cribs carrying light loads. The number of bays in the pier will normally be enough to make the length of the base one-third or more as much as the height of pier (figs. 237, 238, and 251).

b. BRACING. (1) *All possible* bracing frames and tie plates tie trusses together at each side of crib. In a quadruple-truss pier, bracing frames and tie plates overlap (figs. 239, 240, and 241). The entire crib is braced by transoms and sway bracing.

(2) In cribs with vertical panels, transoms are spaced at 10-foot intervals in piers up to 30 feet high, and at 5-foot intervals, in piers 30 feet or higher. In cribs only one bay long, panels of inner trusses are inverted with respect to panels in outer trusses so transoms can be attached to both chords. Sway bracing is on same side of the crib throughout its height. In cribs with two bays of vertical panels panels are placed so transoms and sway bracing are either at center of crib or at its sides. In cribs with four bays of vertical panels, extra sway bracing is added in the outer bays (fig. 237).

(3) In cribs with horizontal panels, panels are right side up with transoms at the bottom; inverted with transoms at the top; or half the panels may be right side up, and the other half inverted so transoms are at both the top and bottom. Vertical-plane cross bracing may be provided by sway braces pinned to the sway-brace slot of the inverted second truss and fastened to the transom at the other end (fig. 239), or the sway bracing may be used as described in paragraph 227*b* (2) (figs. 256 and 257).

(4) In cribs under two-lane panel bridges, transoms are staggered at the center panels (fig. 242). When panels are vertical, transoms in one half, under one lane, are all on top of panel verticals; in the other half, under panel verticals. At the top and bottom of the crib, transoms can be placed only on the inside of panel verticals. Therefore, angles must be welded to the panel chords to take the place of alternate transoms

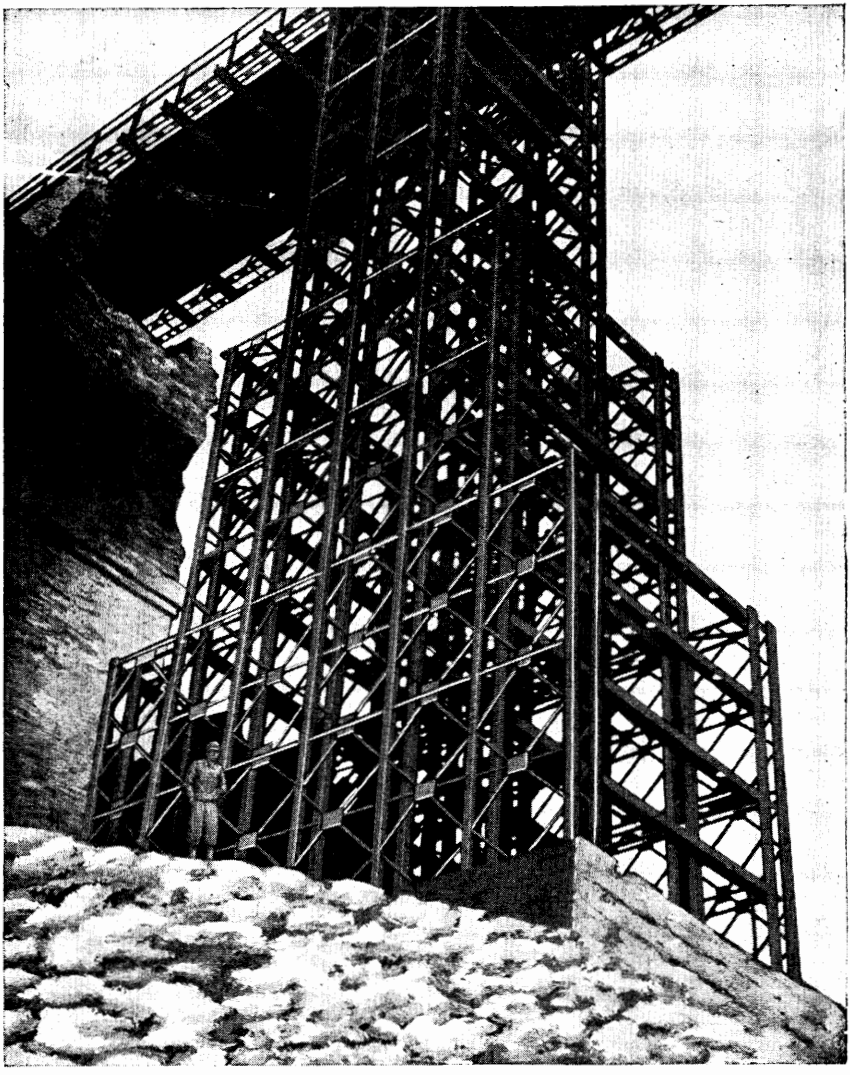
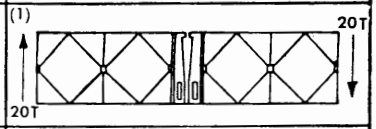
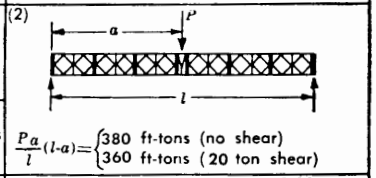
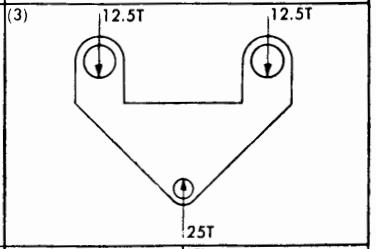
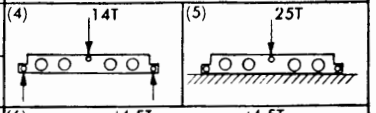
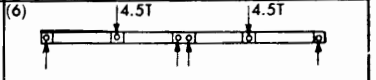
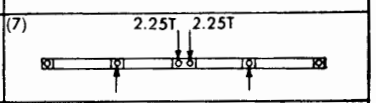
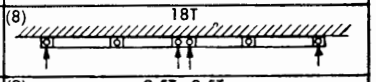
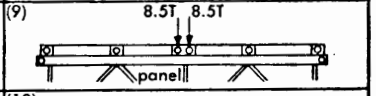
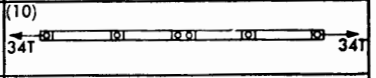
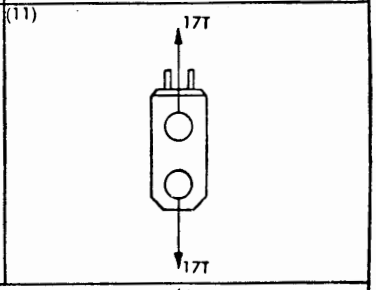


Figure 238. Seven-story D7 (6V–6V–4V–4V–2V–2V–2V) panel crib pier with panels vertical. This is one of two panel piers under three-span 260-foot class 12 bridge built over Senio River near Casola Valsenio, Italy, by British Eighth Army engineers.

Table 68. Strength of Individual Panel Crib Parts

PART	LOAD	STRENGTH (TONS)	ILLUSTRATION
Span junction post	(1) Shear across joint	20	
	(2) Moment of resistance to bending when launching link MK II is in position: With no shear across joint	380 ft-tons	
	With 20 ton shear across joint	360 ft-tons	
Junction link	(3) Vertical load	25	
Junction-link bearing	(4) Load at center when supported at ends only	14	
	(5) Load at center when supported for full length	25	
Crib capsill	(6) When supported at ends and center reinforced holes with load on two intermediate reinforced holes	9	
	(7) When supported at intermediate reinforced holes with load on two center reinforced holes	4.5	
	(8) When supported at end and center reinforced holes with distributed load	18	
	(9) When supported along entire length by a panel chord with load on two center reinforced holes	17	
	(10) Tension between any two reinforced holes	34	
Chord clamp	(11) Tension	17	

Note: See table 72 for strength of launching link MK II, panel pin, panel, and bearing.

(fig. 242). When the panels are horizontal, angles are also used to replace alternate transoms.

(5) High piers are guyed to provide additional lateral stability.

c. BRIDGE SEATING. (1) *Broken span.* If the bridge is broken over the pier so the two spans act independently, span junction posts, junction-links, and junction-link bearings are used (fig. 219).

(2) *Continuous spans.* (*a*) *Bridge fixed to top of crib.* If the crib is pivoted at its base so the bridge is fastened directly to the crib, chord clamps are slipped between the channels of the bridge chord and pinned to the crib capsill (fig. 230).

(*b*) *Rocker bearing at top of crib.*

1. Figure 209 illustrates rocker bearings using panel crib parts. This type of rocker bearing rests on a base plate on top of

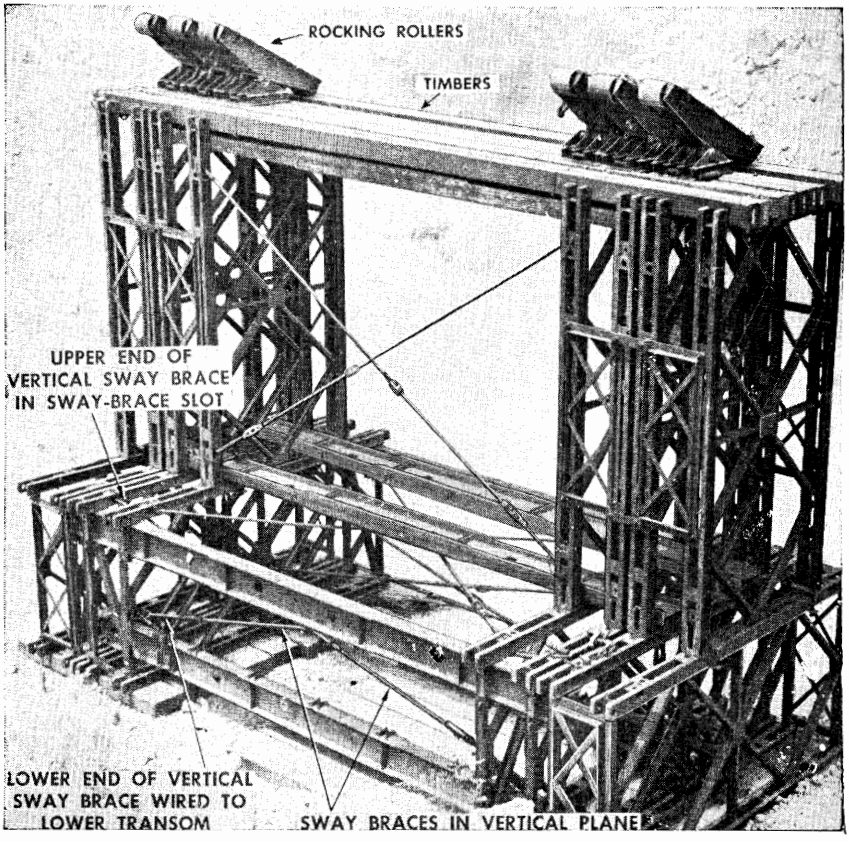


Figure 239. QD(1H–1V) panel crib pier with rocking rollers in position for launching bridge. Expedient bridge seating is made from timbers laid on end panel member. Connection between horizontal and vertical panels is same as in figure 252. Sway braces fastened at one end to sway-brace slots in inverted second truss and at other end to bottom transom are used as expedient vertical-plane bracing between horizontal panels.

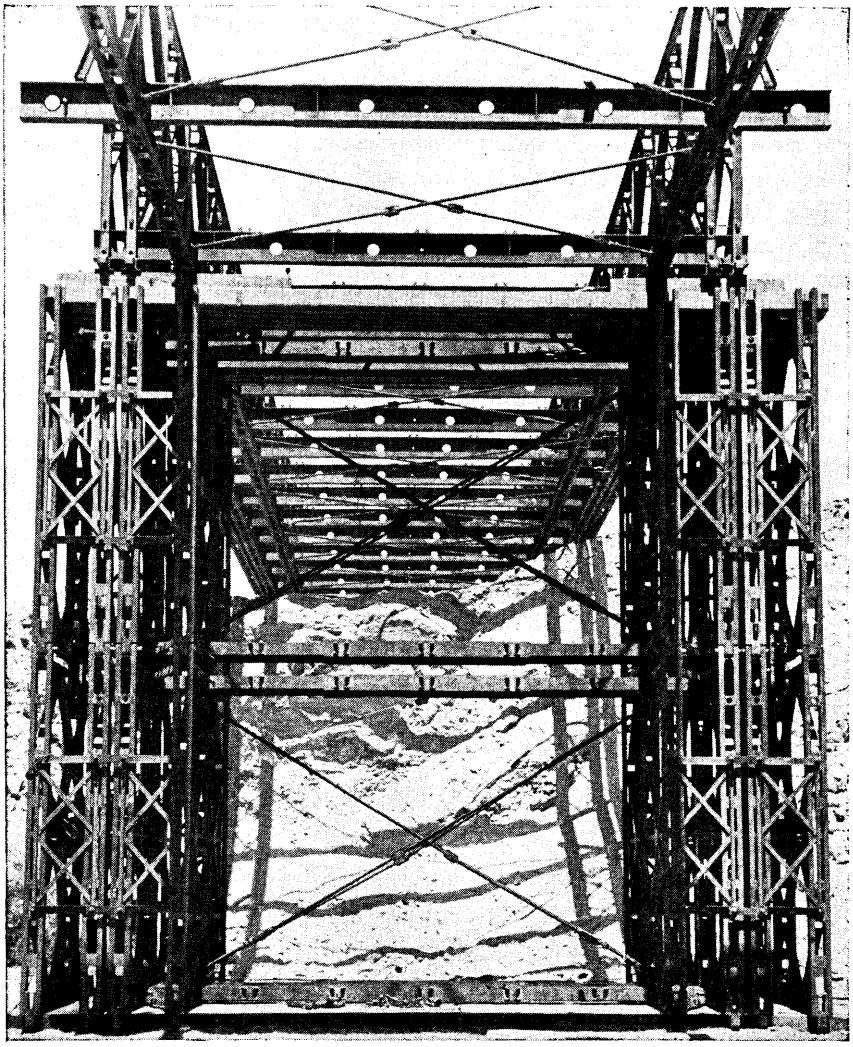


Figure 240. End view of QD (2V-2V) panel crib pier. Overlapping tie plates and bracing frames are held by bracing bolts (see fig. 241).

the pier. A wide platform on the top of the pier, to allow some leeway in positioning the base plates, may be constructed from transoms and ramps welded in place as described in paragraph 227*a* (2).

2. An expedient rocker bearing may be made from one or two transverse beams set on the top of the pier (fig. 243). Bearing must be under a panel vertical or the junction of panel diagonals. Figures 209 and 210 illustrate two other expedient bearings.

d. CRIB BASE. (1) *Fixed base.* If panels in the first story of the pier

are horizontal, they may be set directly on a timber or masonry pier foundation (figs. 231 and 233). If panels in the first story are vertical, the female jaws of the panels are pinned to crib bearings which set on timber or steel footings (figs. 232 ② and 235 ②).

(2) *Rocker base.* The rocker may consist of a crib bearing seated on a standard bearing (figs. 228 ③ and 230 ①), or an inverted junction-link bearing set on an inverted junction-link (fig. 230 ②).

(*a*) If the panels in the lower story of the pier are horizontal, a crib capsill is fastened by chord clamps to the bottom chord. This crib capsill is then pinned directly to the crib bearing (fig. 230 ①), or by chord clamps to the inverted junction-link bearing (fig. 230 ②).



Figure 241. Close-up view of bracing in a quadruple-truss crib pier. Tie plates overlap bracing frames and are held by bracing bolts. Sockets are removed from tie plates and washers from bolts so extra long bolts are not required.

(*b*) If there is one bay of vertical panels with female end down in the pier, the female jaws are connected by chord clamps to the top of a junction-link bearing which is pinned to a crib bearing (fig. 232 ①).

(*c*) If there are two bays of vertical panels, the two adjacent-center female jaws are pinned to a crib bearing which is on a standard bearing (figs. 235 ① and 244).

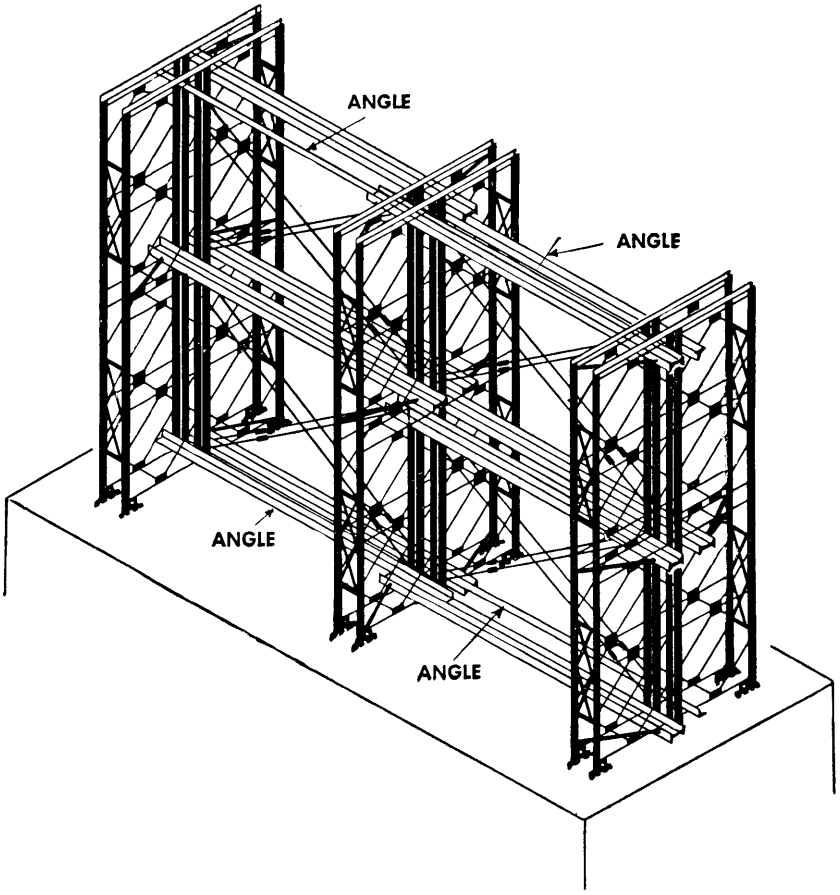


Figure 242. DD(2V–2V) panel crib pier for a DS–DD two-lane panel bridge. Transoms are staggered at center panels. At top and bottom, angles are welded to chords of panels in crib to replace alternate transoms.

227. Expedient Construction

a. Standard Truss Arrangement. (1) *Improvised panel-crib parts.* If no special panel crib parts are available, expedient parts can be improvised.

(*a*) *Expedient capsills.* Panel chords or any pair of 4-inch or larger channels with holes drilled at the desired spacing can be used for improvising crib capsills.

(*b*) *Expedient crib bearings for base of pier.* Angles or lugs with pin

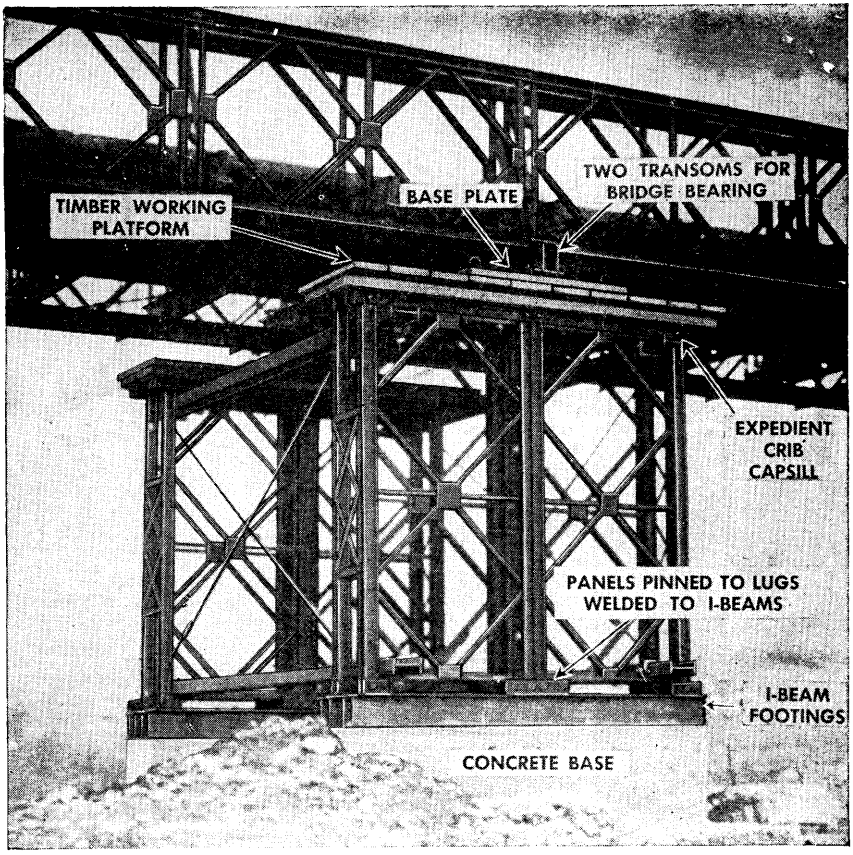


Figure 243. View of DS(2V) pier on expedient footing and with expedient bridge bearing. Vertical panels are pinned to lugs welded to I-beam footings.

holes in their upright parts can be fastened to the crib foundation and the panels pinned to them (fig. 243). Another expedient is to have the panel pins in the female jaws of the vertical panel bear on top of an I-beam or rail (fig. 245). A load of 7½ tons per panel pin is allowed on unstiffened beams of web thickness ¼- to 5/16-inch. Greater loads are permitted if web is stiffened or if web thickness is greater than ⅜ inch.

(*c*) Other special panel crib parts are not readily improvised.

(2) *Construction without panel-crib parts.* (*a*) *Bridge seating.*

1. Figure 246 illustrates the use of transoms and ramp sections to provide a flat top in the crib for the base plates under the rocker bearing. With this type pier cap, the bridge may be as much as 6½ inches off the center of the pier. This is made up from a 4½-inch movement of the bearings on the base plate and a 2-inch movement of the base plate on the pier top. Figure 247 illustrates the vertical dimensions and capacities of piers with flat top and rocker bridge bearing.

2. The bridge seating may consist of timber laid on the end-panel member in a lateral direction, but is allowed slight movement in a longitudinal direction.
3. The pier can also be pinned to the bridge by pinning male lugs of the two inside posts of the pier to the lower bridge chord and inserting the outer posts in the space between channels of the lower chord (fig. 249). These outer posts just miss the center vertical in the bridge panels. If the outer-post shoulders are cut down enough to permit deflection in the span, this connection can be used with a rigid pier base. The top chord of the bridge is left unpinned so the two spans act independently.

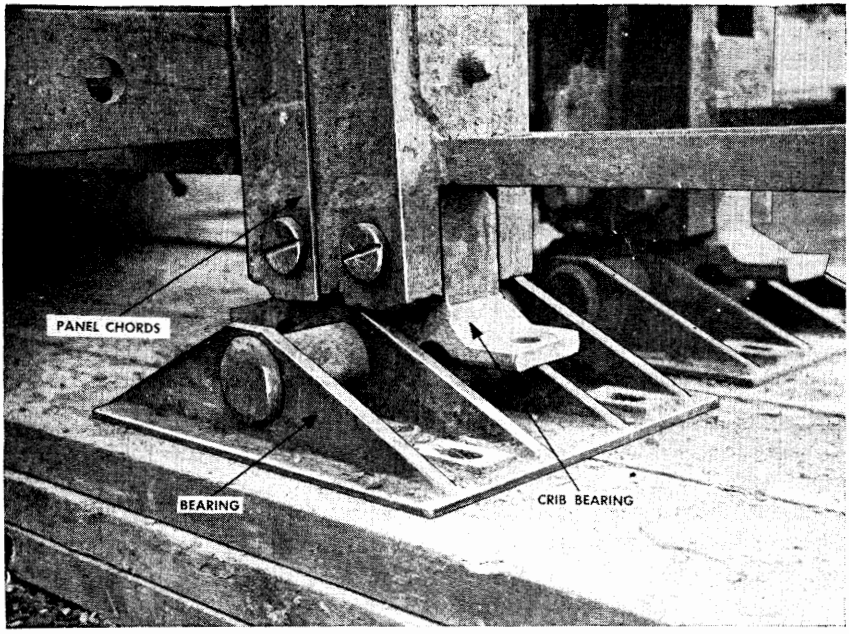


Figure 244. Rocker bearing at base of crib with two bays of vertical panels. The two adjacent center-female jaws are pinned to a crib bearing which rocks on a standard bearing.

4. Another method is to insert the male lugs of the pier posts into recesses in the lower bridge chords as in figure 250. Clamps made from two tie plates and riband bolts anchor the bridge to the pier.
5. The last three methods are limited because there is only one pier position in which the lugs fit without interfering with the bridge chord spacers.

(*b*) *Crib base.* Without special panel crib parts, the crib is set on timber. The cribbing is arranged to bear on the bottom panel member (fig. 251).

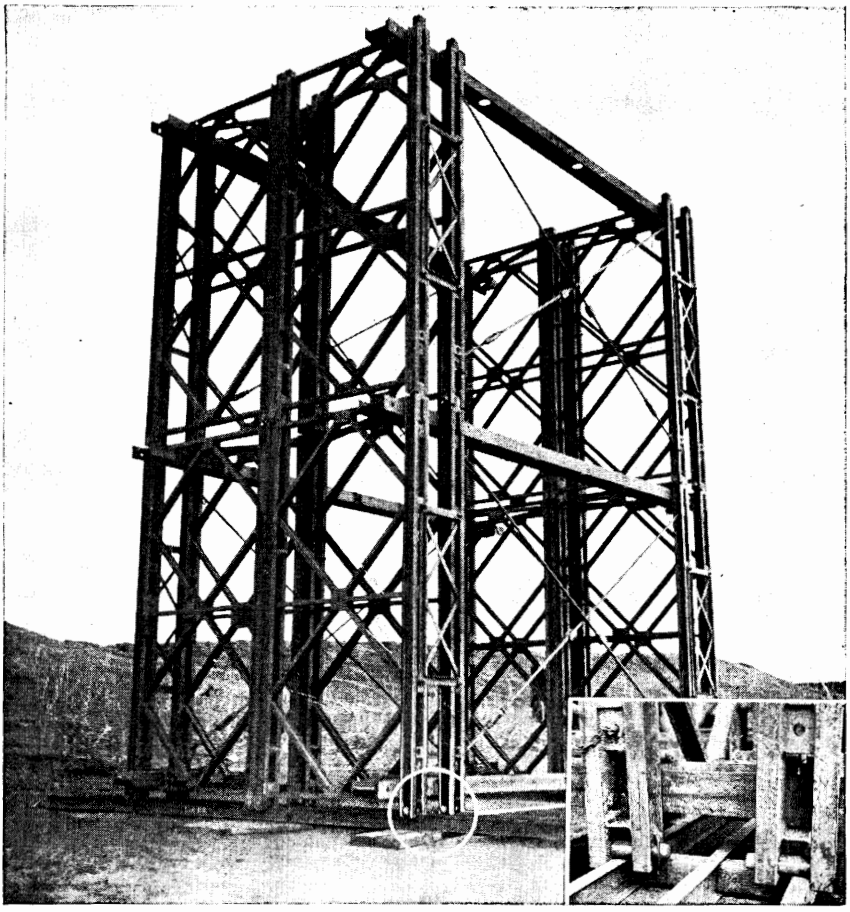
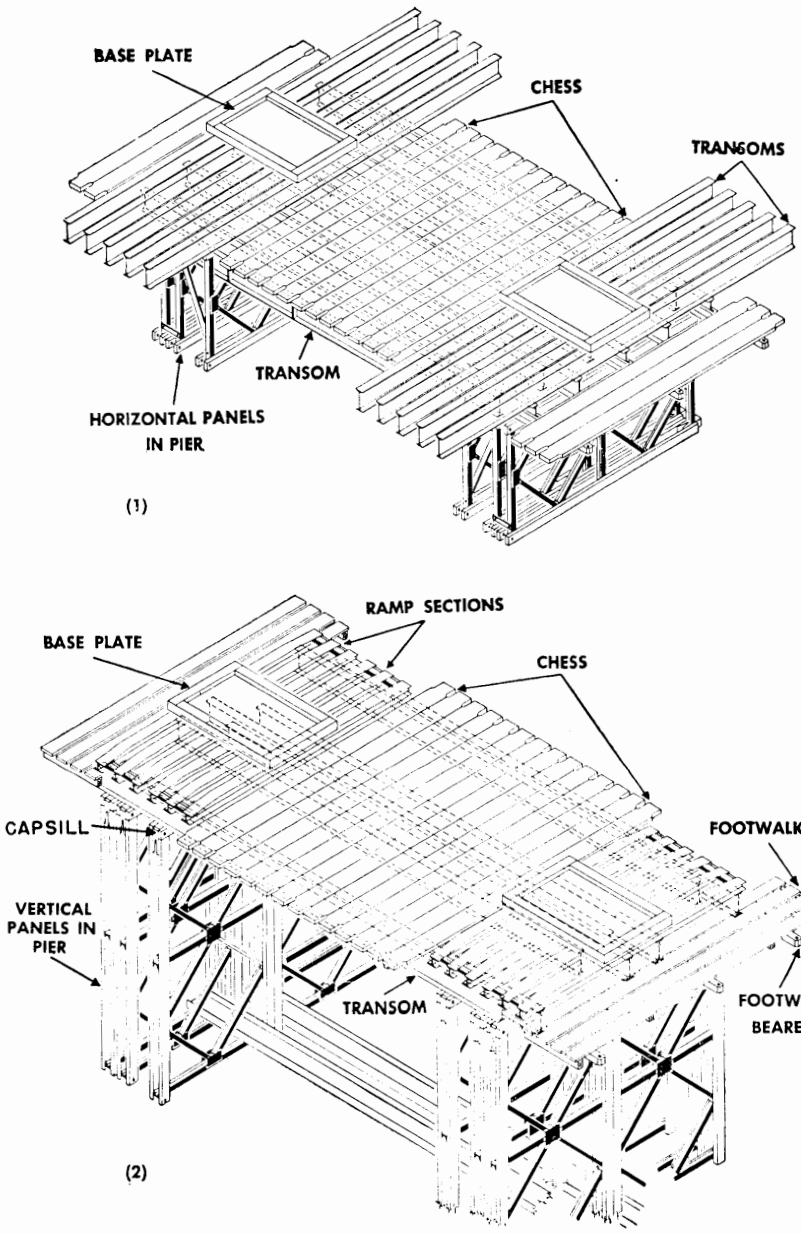


Figure 245. DD(2V–2V) pier. Inset shows close-up of panel pins bearing on I-beam footings. Railroad rails may be used instead of I-beams.

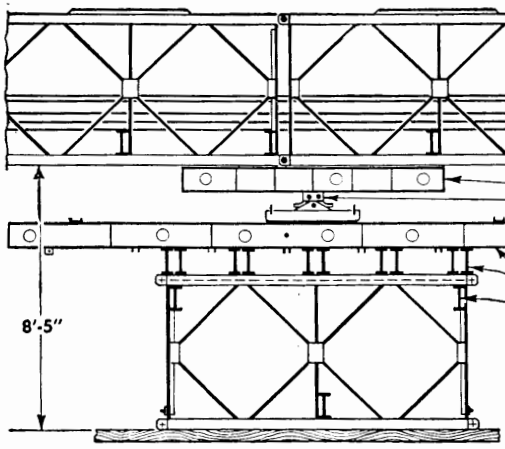
(*c*) *Connection between horizontal and vertical panels.* Figure 252 shows a method of connecting horizontal and vertical panels in a panel crib. The reinforcing plate at the bracing-bolt hole is cut away, and the male lugs of the vertical panel are slipped between the channels of the horizontal chord. The panels are tied together by an expedient clamp made from tie plates and riband bolts.

b. NONSTANDARD TRUSS ARRANGEMENT. (1) *Trusses.* (*a*) *Panels transverse to axis of bridge.* Expedient panel cribs can be built with panels transverse to the bridge axis as in figures 253 and 254. This type



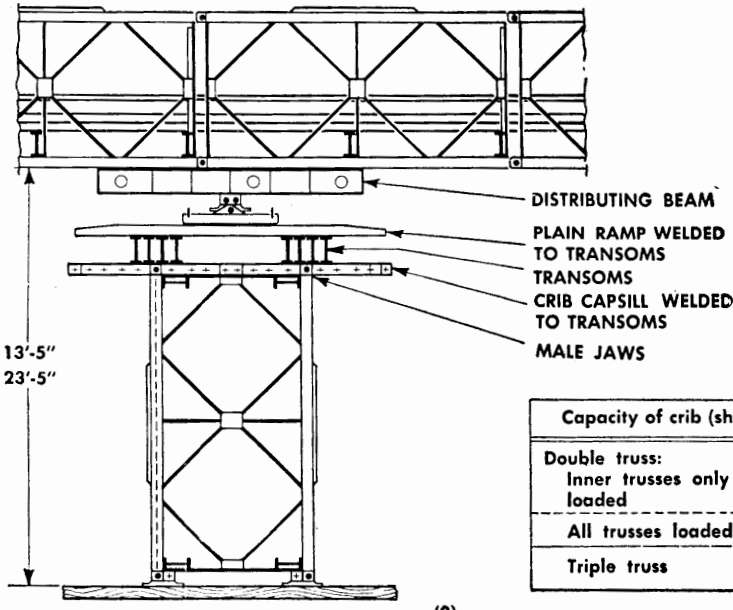
(1) *TS(III) panel crib pier.*
(2) *TS(2V) panel crib pier.*

Figure 246. Expedient use of transoms and ramps to provide a flat top on the crib. With this type pier top, the bridge may be as much as 6½ inches off the center of the pier. Chess or timbers laid across transverse transoms provide a working platform.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	65
All trusses loaded	110
Triple truss	155

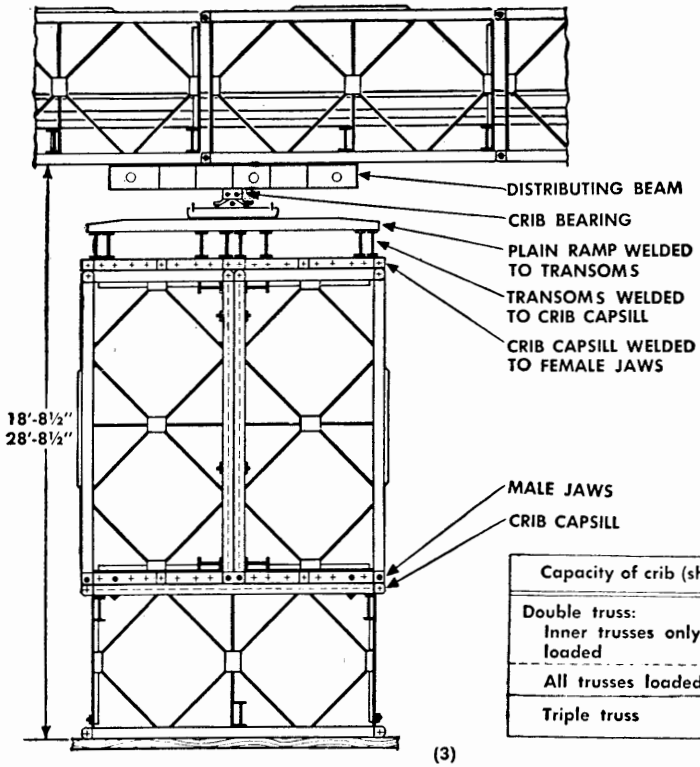
①*Single-story single-bay crib with panels horizontal*



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	65
All trusses loaded	110
Triple truss	155

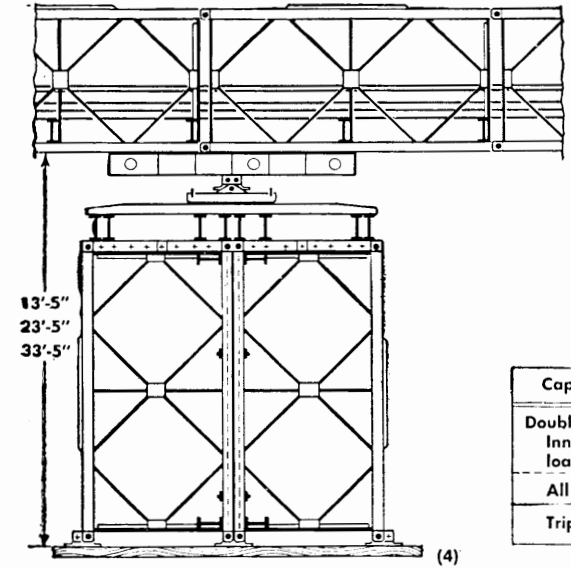
②*Single- to double-story single-bay crib with panels vertical*

Figure 247. Panel crib piers with expedient flat tops and rocker bridge bearing under continuous bridge.



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	65
All trusses loaded	110
Triple truss	155

③*Double- to triple-story double-bay crib with panels both horizontal and vertical*



Capacity of crib (short tons)	
Double truss: Inner trusses only loaded	65
All trusses loaded	165
Triple truss	220

④*Single- to triple-story double-bay crib with panels vertical*

Figure 247.—Continued.

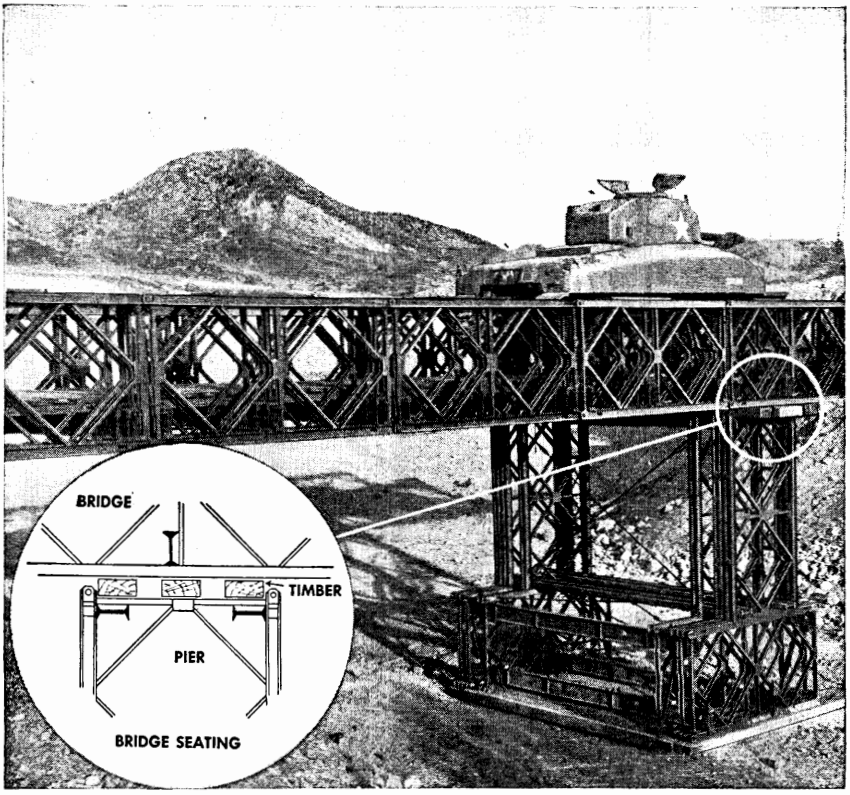


Figure 248. TD(III–IV) panel crib pier with expedient bridge seating of timber. Expedient connection between vertical and horizontal panels is same as that in figure 252.

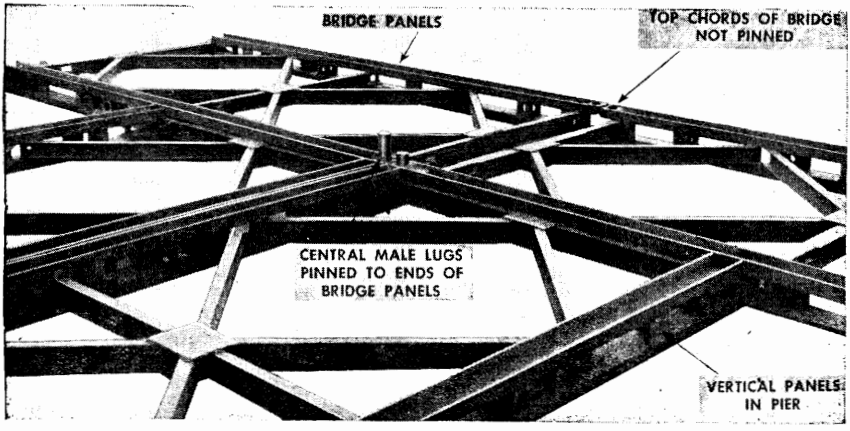


Figure 249. Expedient method of connecting bridge to crib pier. Bridge pinned to two inside posts of vertical panels in a double-bay panel crib pier. Outer post shoulders of pier are cut down so the two spans act independently.

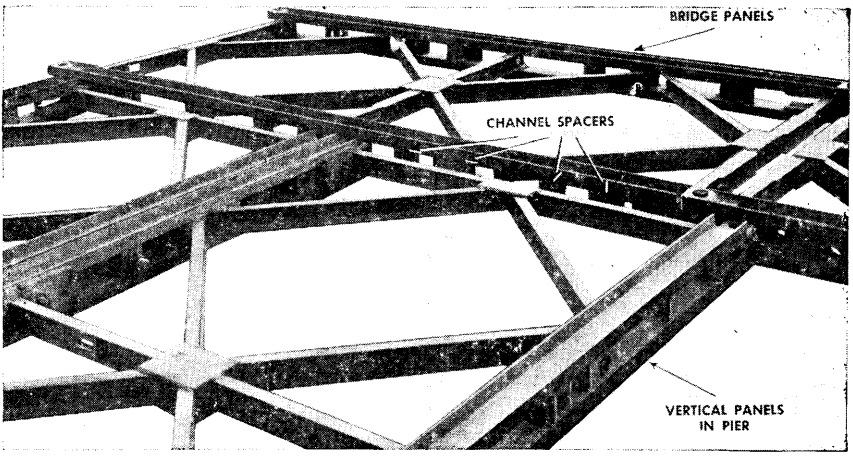


Figure 250. Expedient method of connecting bridge to crib pier. Male lugs of vertical panels fit between channels of lower chord of bridge. The picture shows the one position in which this can be done without the male lugs interfering with channel spacers.

of construction is useful when pier is skewed or when pier foundations are restricted. Two panels pinned end-to-end give a 20-foot pier width. In figure 253, trusses are braced together by bracing frames in every possible position. Bracing frames are overlapped at each end and 5-inch-long bolts replace standard bracing bolts. In lighter one-story piers, as in figure 254, the two panels are connected by tie plates.

(*b*) *Crib cells.* The crib may be built in the form of two cellular columns, one under each side of the bridge as in figure 255. Each column is made of four vertical panels arranged in a square. Chords of adjacent panels are welded to angles. Panels are capped with improvised capsills, and timber cribbing is laid across the capsills. The crib base is similarly constructed. The two columns are tied together by tie rods welded between them.

(2) *Bracing.* More than one story of horizontal panels can be used if additional expedient vertical cross bracing is added.

(*a*) Figure 256 shows sway braces in the vertical plane bracing a double-story pier to carry light loads. Tie plates are bolted to one end of the sway braces as an extension. Lengthened sway braces are bolted diagonally between the lower bracing-frame hole in the end vertical of one truss to the upper bracing-frame hole of the end vertical on the opposite truss.

(b) As an alternative, vertical sway braces can be used in each story. The braces pin to the bottom chord of the second panel, bend up, and are welded to the underside of the top chord in the opposite inner truss (fig. 257).

(*c*) For heavier loads, channel sections welded across each end of the crib give a more rigid cross brace (fig. 257).

228. Erection

a. Assembling Crib Pier. (1) *Without equipment.* The procedures below may be followed when erecting piers by man power.

(*a*) Lay out and accurately level pier foundation. Mark panel positions accurately. Position crib bearings where these are used.

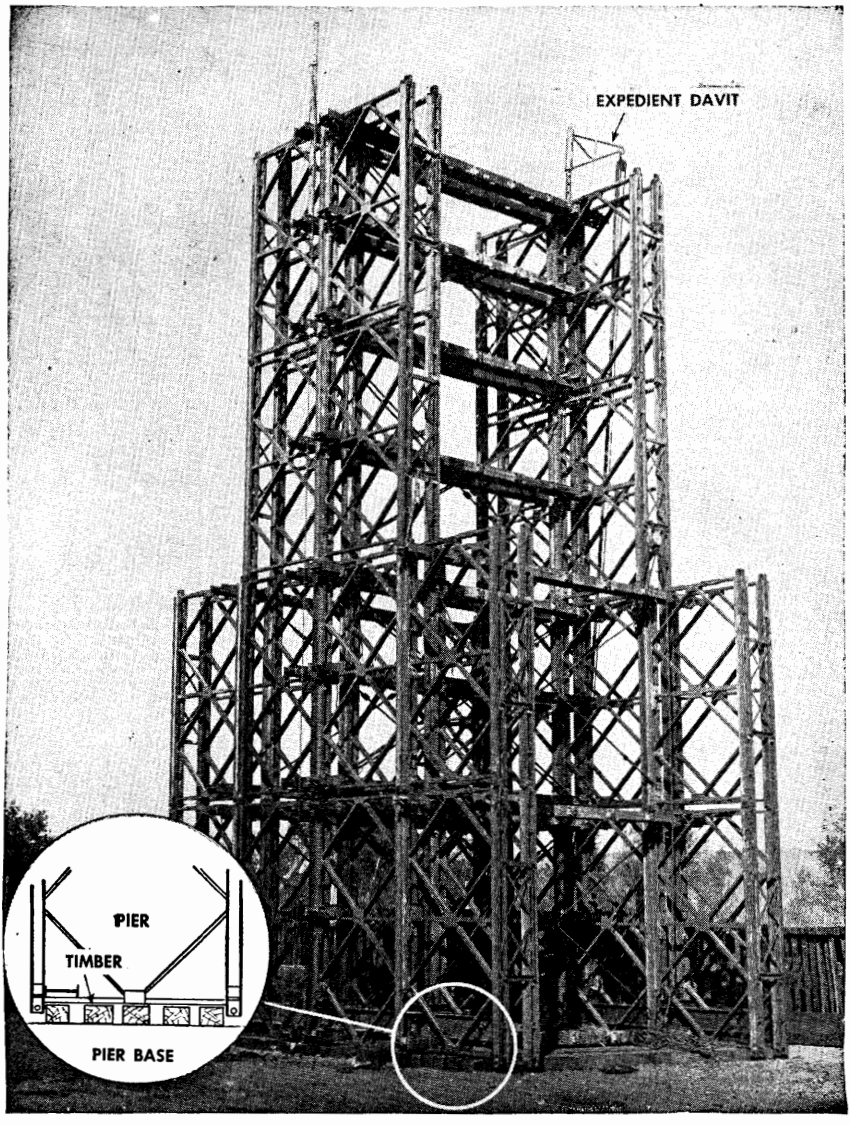


Figure 251. DQ(4V–4V–2V–2V) panel crib pier. Crib rests on expedient seating of timbers which bear against the bottom panel member.

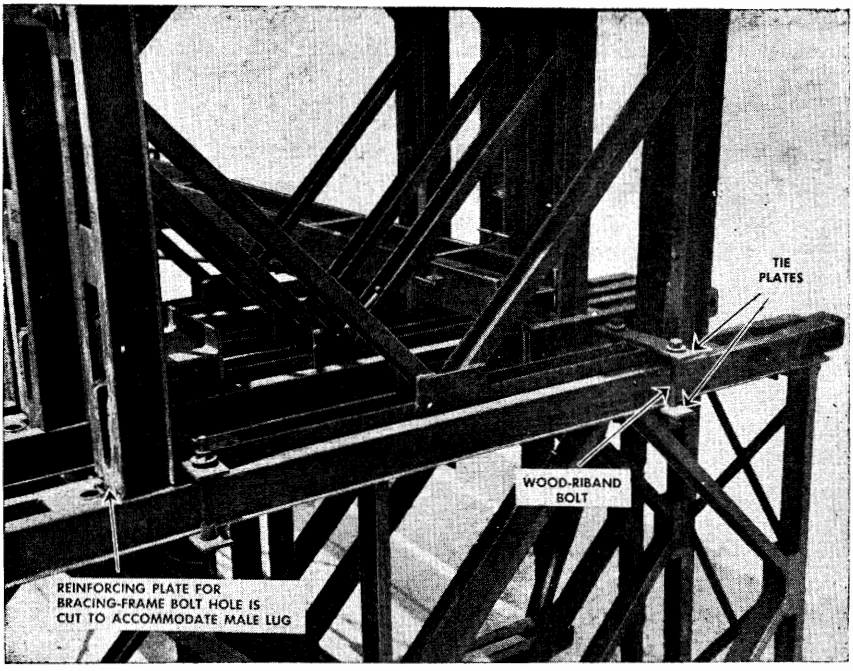


Figure 252. Expedient connection between horizontal and vertical panels in a panel crib pier. Reinforcing plate at the bracing-bolt hole is cut away, and male lugs of vertical panel are slipped between chord channels of the horizontal panel. Panels are tied together by an expedient clamp made from tie plates and riband bolts.

(*b*) Carry up panels for trusses on each side of crib and lay flat on base with female jaws pointing to bearings. Lift up panels and pin to bearings.

(*c*) Fasten transoms, rakers, bracing frames, and sway braces in first story. Check that the panels are vertical and square to center line.

(*d*) Construct a working platform of transoms and chess in the first story. Haul panels up singly and lay flat on platform with female jaws opposite top lugs of first story. Lift each panel in turn and pin into position.

(*e*) Fasten transoms and bracing in second story and again check that crib is vertical and square to center line.

(*f*) Repeat for number stories required. An improvised gin pole (fig. 258) or davit may be used to lift panels and transoms to upper stories.

(2) *With mechanical equipment.* (*a*) If site conditions permit, a truck-mounted crane can be used to erect 20-foot high crib piers and the two lower stories of higher piers. Bays are assembled on the ground nearby, and the assembly is lifted into place by the crane (fig. 259). If the pier is surrounded by water, the crane can be mounted on a raft

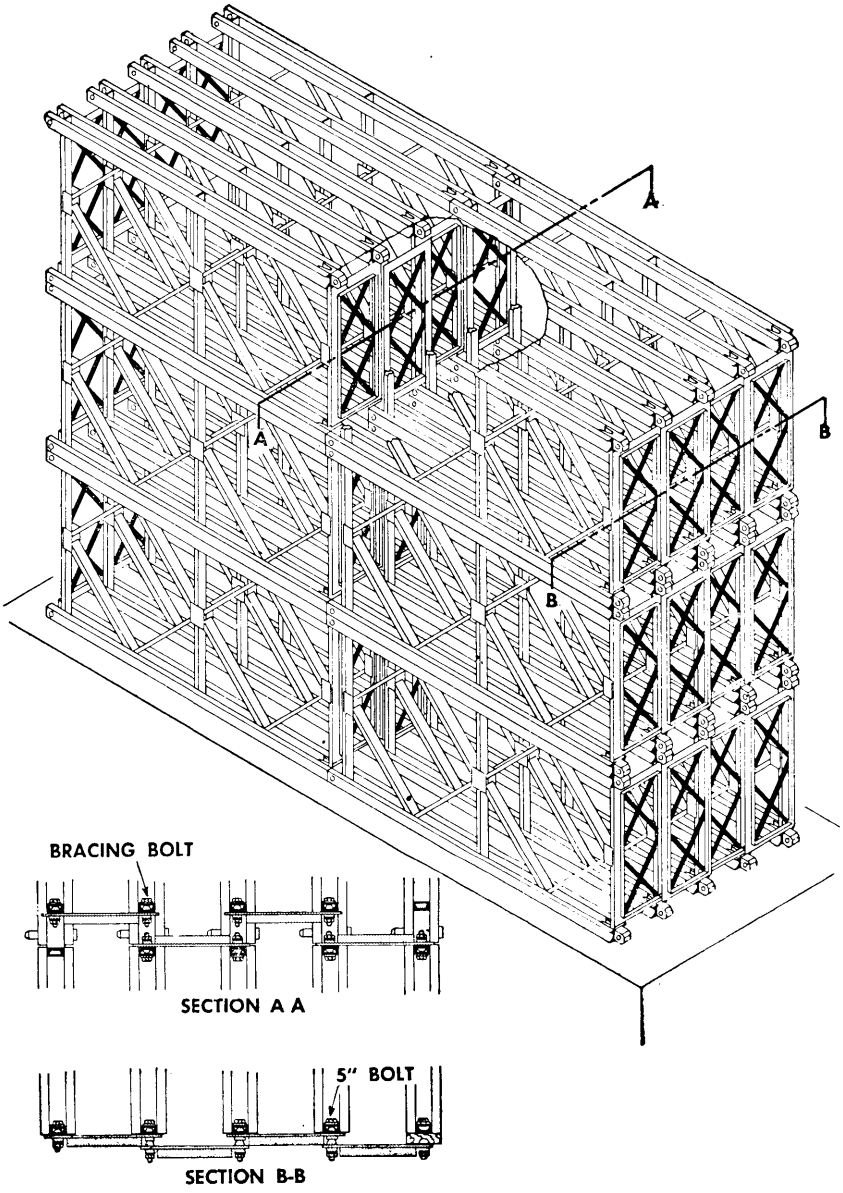


Figure 253. Expedient panel crib pier with panels transverse to axis of bridge. Trusses are braced together by bracing frames in every possible position. The bracing frames are overlapped at each end and 5-inch-long bolts replace the standard bracing bolts.

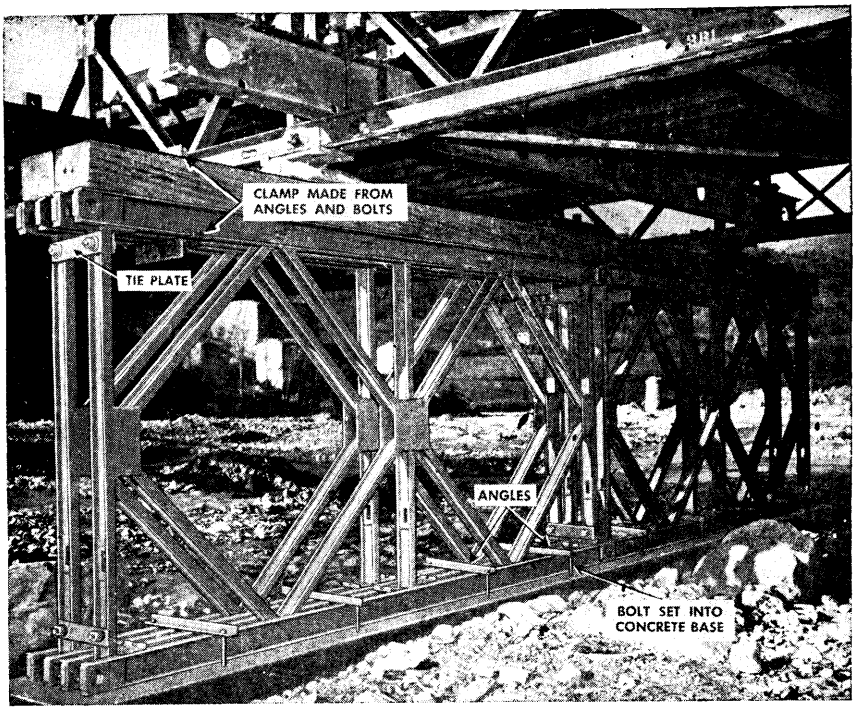


Figure 254. Expedient panel crib pier with panels transverse to axis of bridge. Two trusses in each pier are tied together with tie plates. Piers are anchored to foundation by lag bolts set in concrete. Wood capsills are tied to pier by expedient clamps made from angles and bolts.

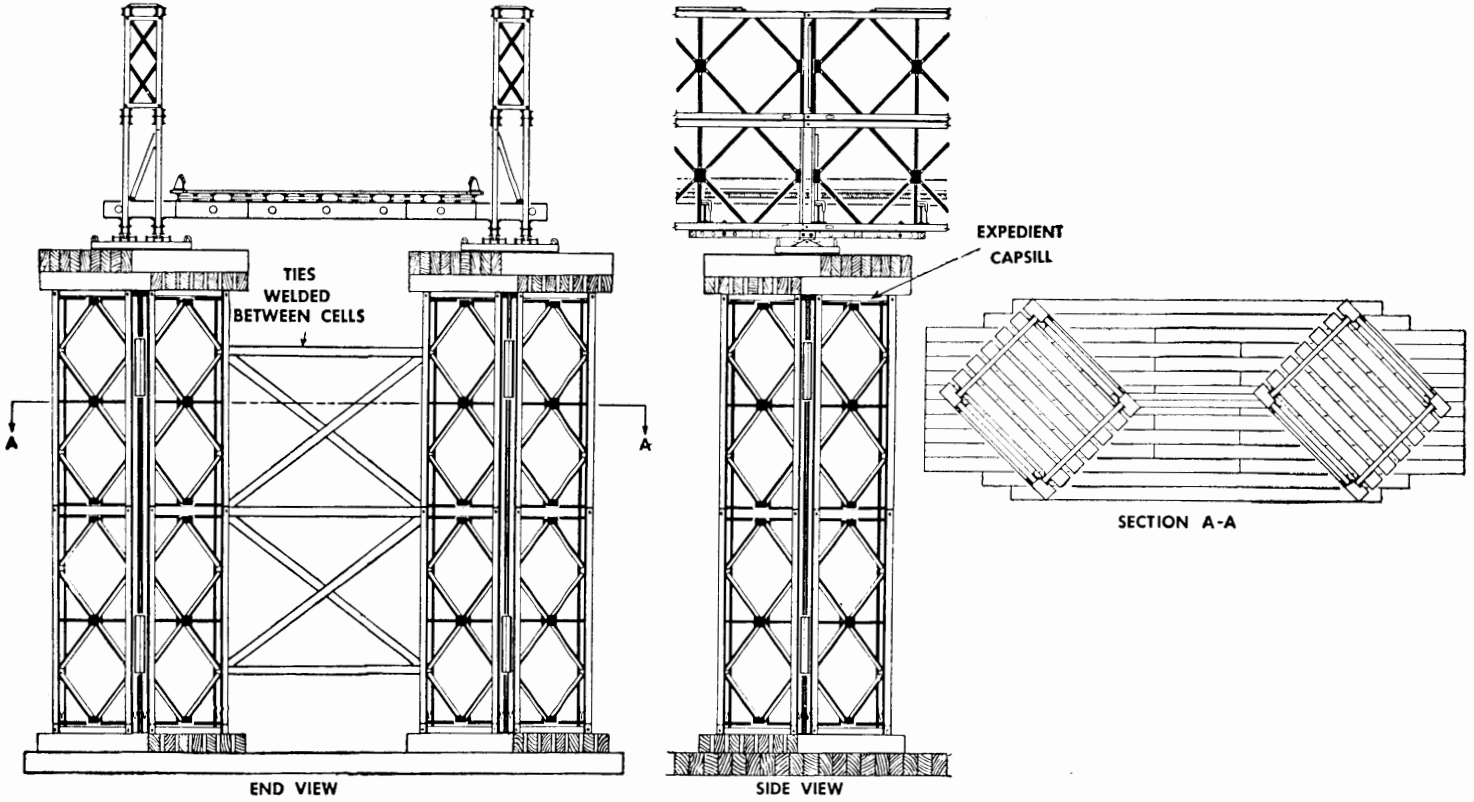


Figure 255. Cellular type panel crib pier.

(figs. 260 and 261). For erecting higher piers, a long-boomed crane can be used (fig. 262).

(*b*) If pier construction is between existing high banks or piers, cranes, high lines (fig. 262) with winches on banks or existing piers can be used to lift panels into place.

(*c*) If the bridge without the pier will carry the erection equipment, the pier can be constructed from the bridge. A truck crane (fig. 263) or rope tackle can be used to lower the panels over the side of the bridge into place on the pier. When all panels in the pier are in place, bridge is jacked up over the pier to eliminate sag and allow placing of bridge seating. This last step can be eliminated by leaving bridge on rollers at each abutment until after pier is completed. Rollers must be blocked up enough to keep bottom chord above level of top of finished pier.

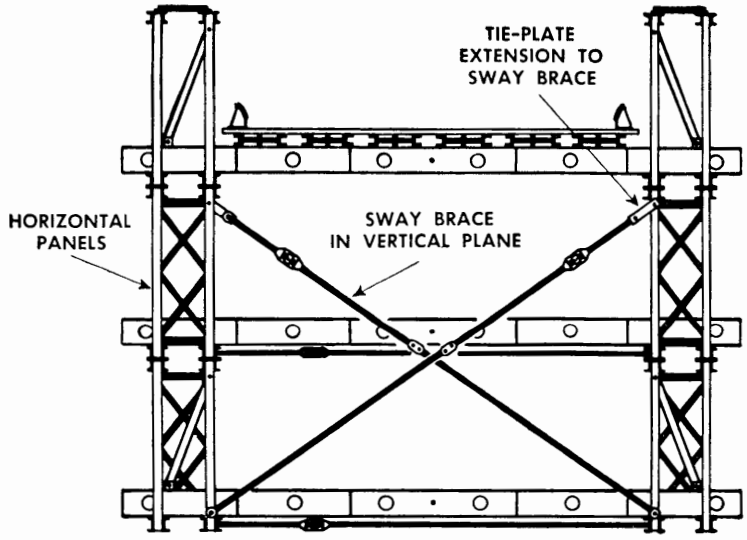


Figure 256. Sway-brace cross bracing in two-story panel crib pier.

(*d*) In continuous-span bridges, the pier can be constructed by working from the end of a cantilever span.

b. Launching Bridge. Rocking rollers are placed on cribbing on top of the piers before launching the bridge (fig. 264). The bridge is pushed out over these rollers until the entire bridge is over all the spans. The bridge is jacked up, rollers and cribbing are removed, and then the bridge is jacked down onto its seatings on the piers (fig. 265). A temporary working platform may have to be built for operating the jacks. Figure 266 illustrates a temporary platform on top of crib for use under a broken span bridge. Figure 246 illustrates two working platforms for use under a continuous bridge. If the bridge is to consist of independent spans, the girders are disconnected at each pier.

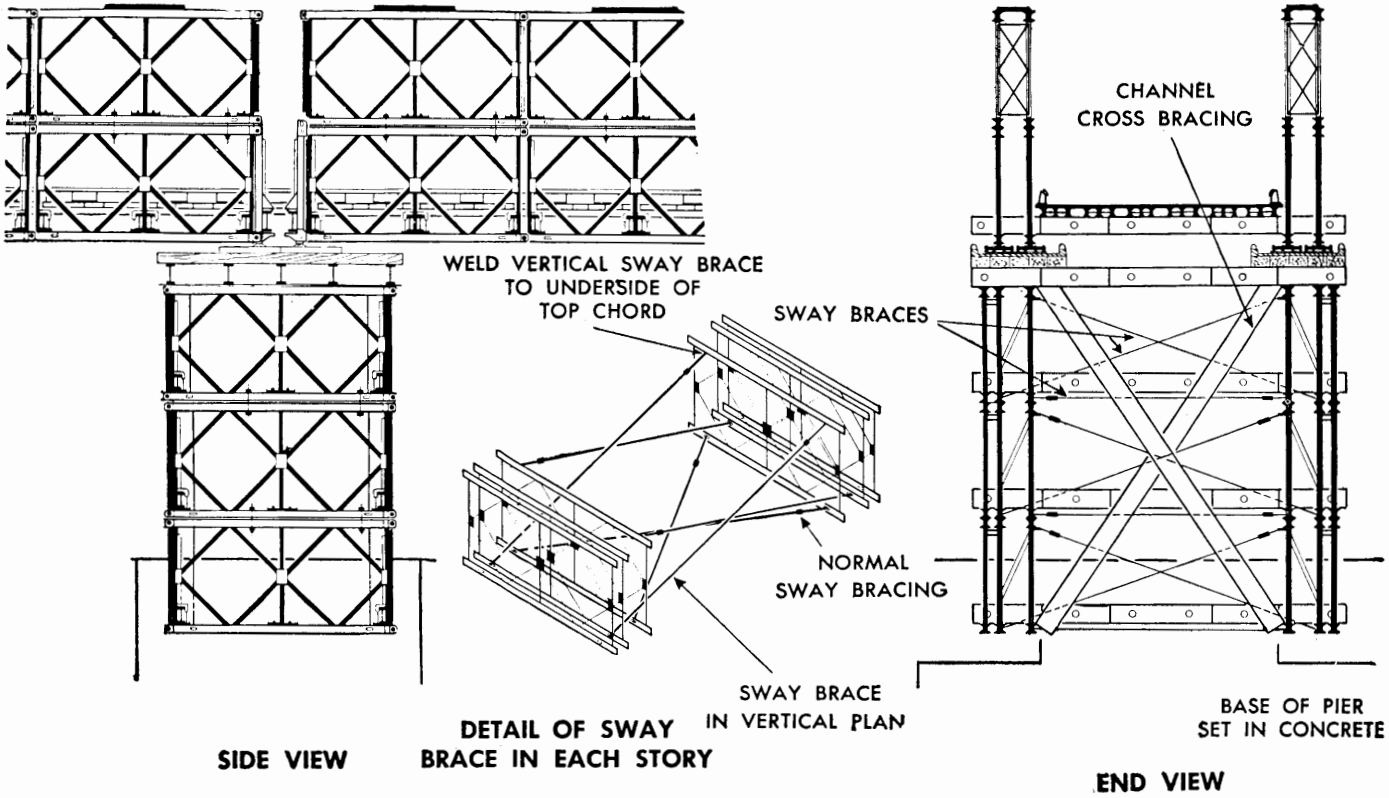


Figure 257. Expedient cross bracing in three-story panel crib pier.

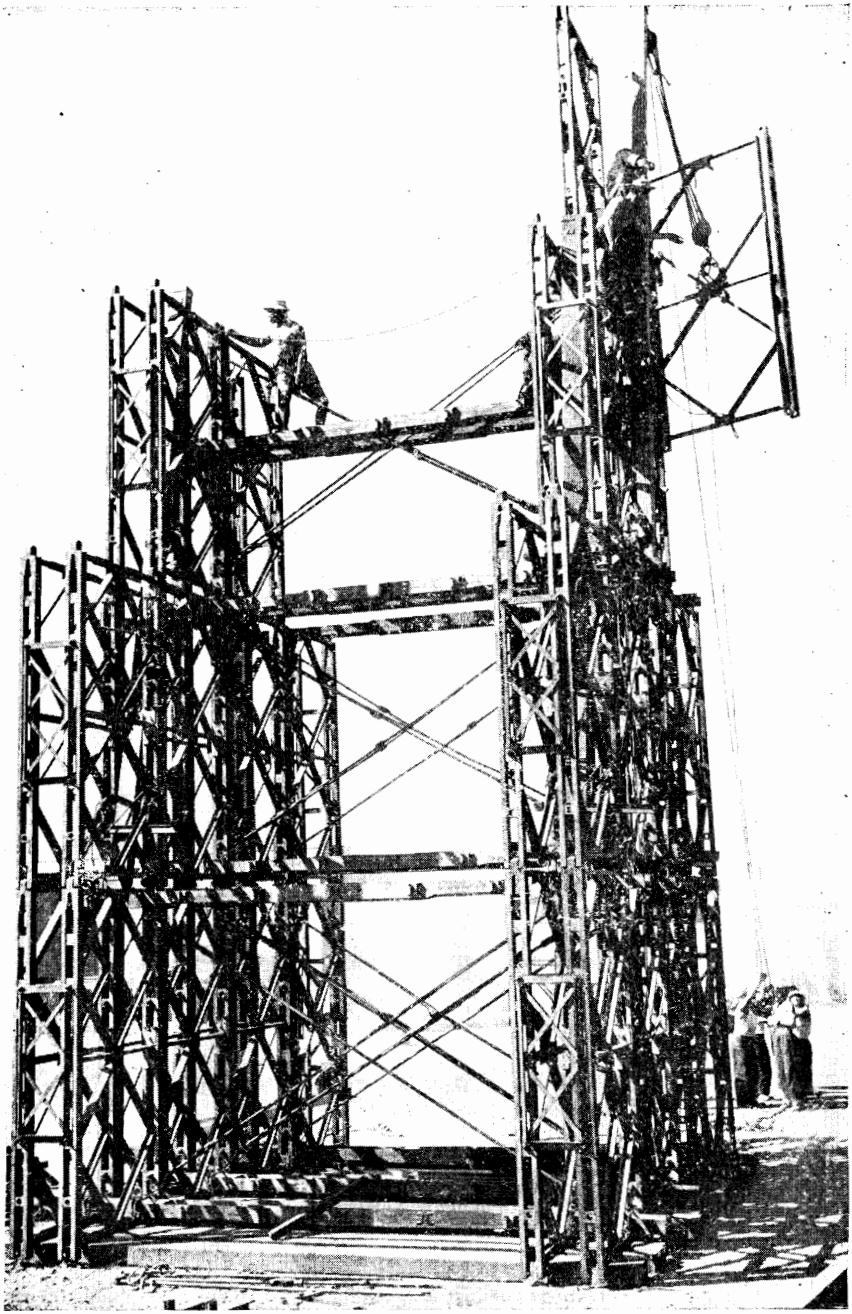


Figure 258. Gin pole improvised from timber raising panels into position in the upper stories of a panel crib pier.

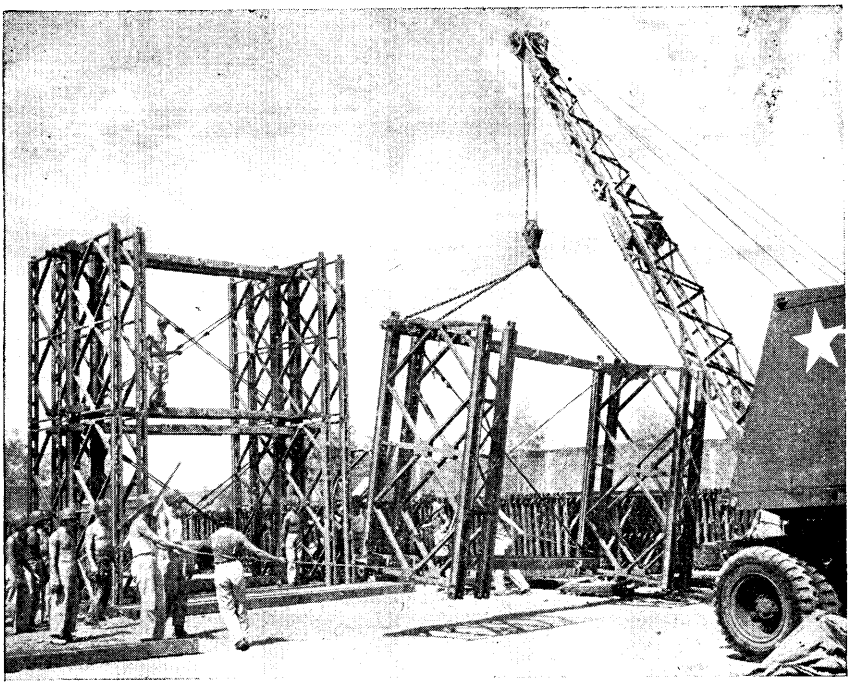


Figure 259. Truck-mounted crane lifting crib assembly into position for lower part of pier.

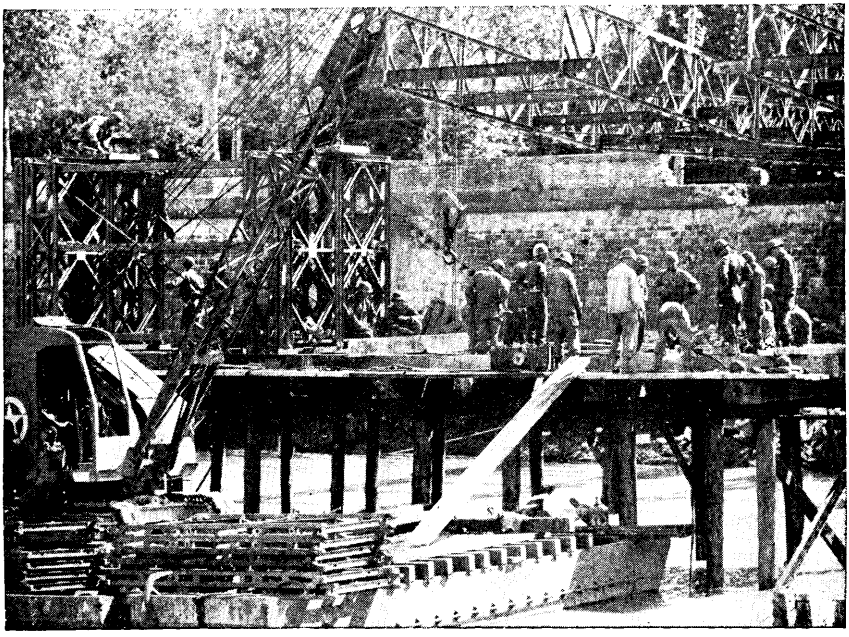


Figure 260. Crane on ponton raft ready to erect second pier on pile pier. Crib parts are stacked on the raft.

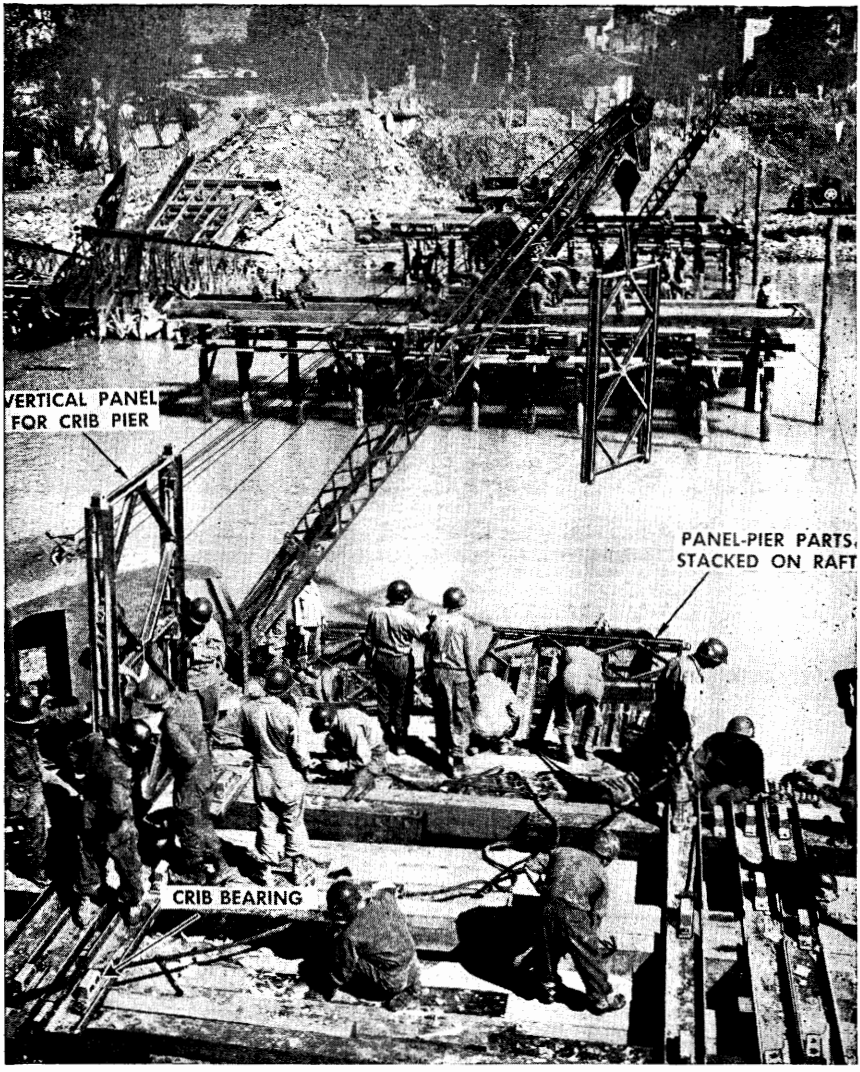


Figure 261. Start of erection of panel crib pier on pile pier. Crane lifts panels into position on crib bearings set in steel channels to distribute load over piles.

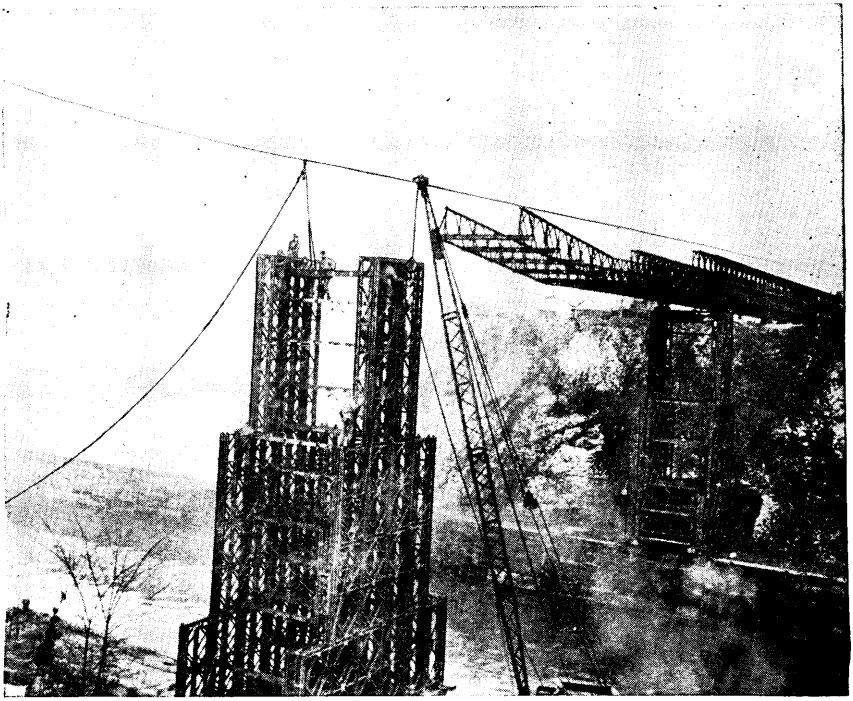


Figure 262. Erection of five-story panel crib pier using a highline and crane. These two five-story crib piers were built by engineers of the Ninth Army to support a 324-foot class 40 panel bridge over the Albert Canal near Maastricht, Holland.

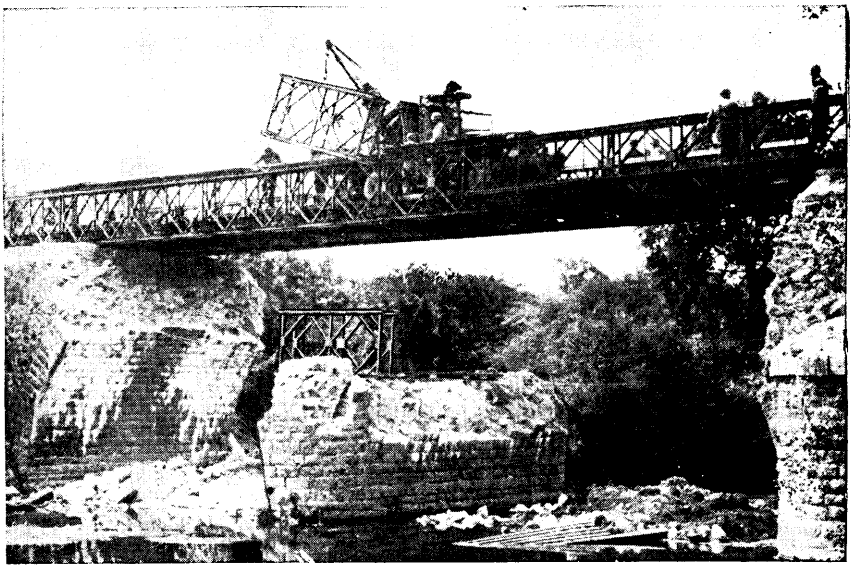


Figure 263. Constructing crib pier by using a wrecker to lower panels over side of existing bridge.

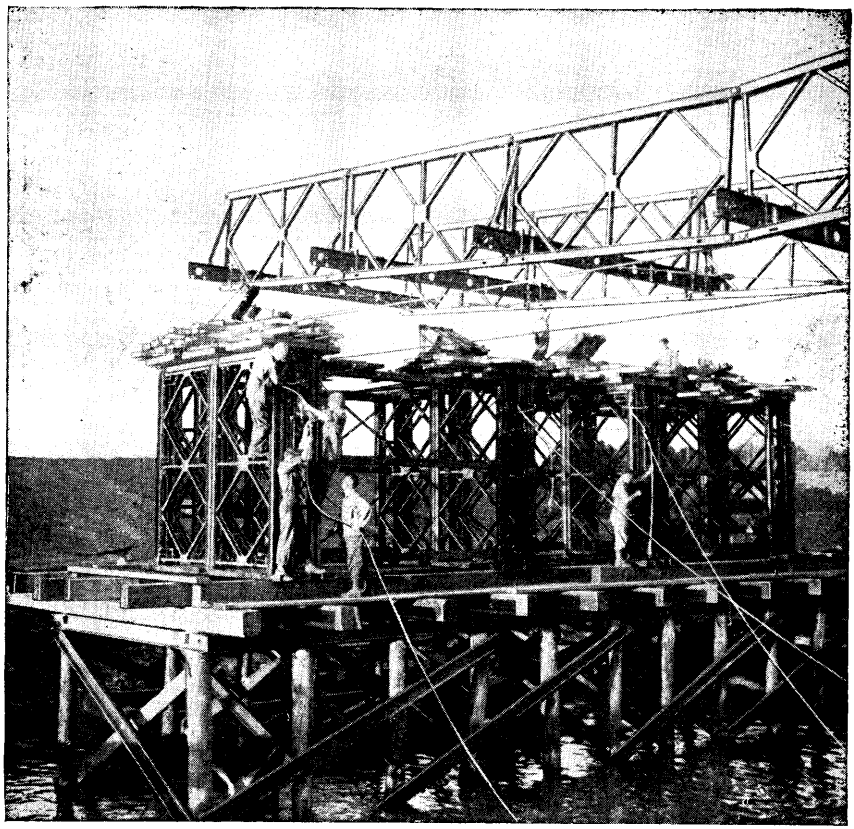


Figure 264. Rocking rollers in position on top of panel crib pier before launching bridge.

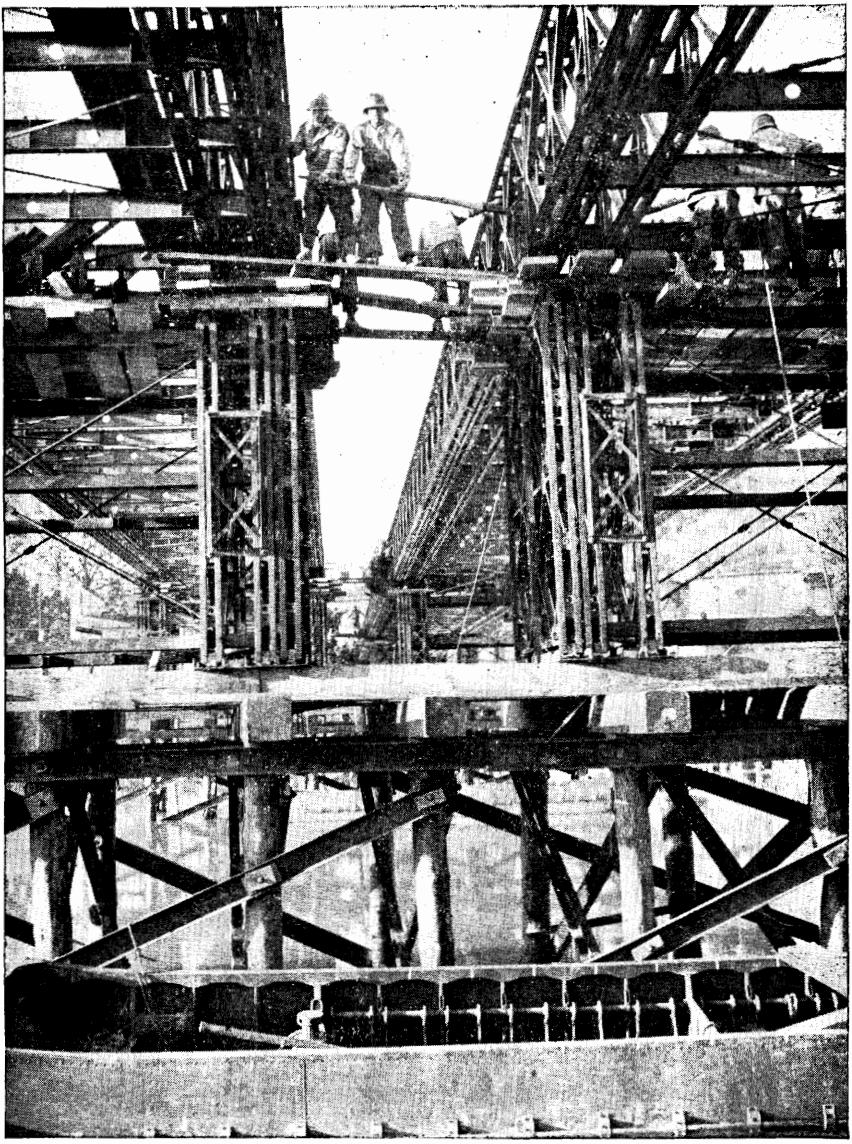


Figure 265. Two panel bridges being jacked down onto panel crib piers.

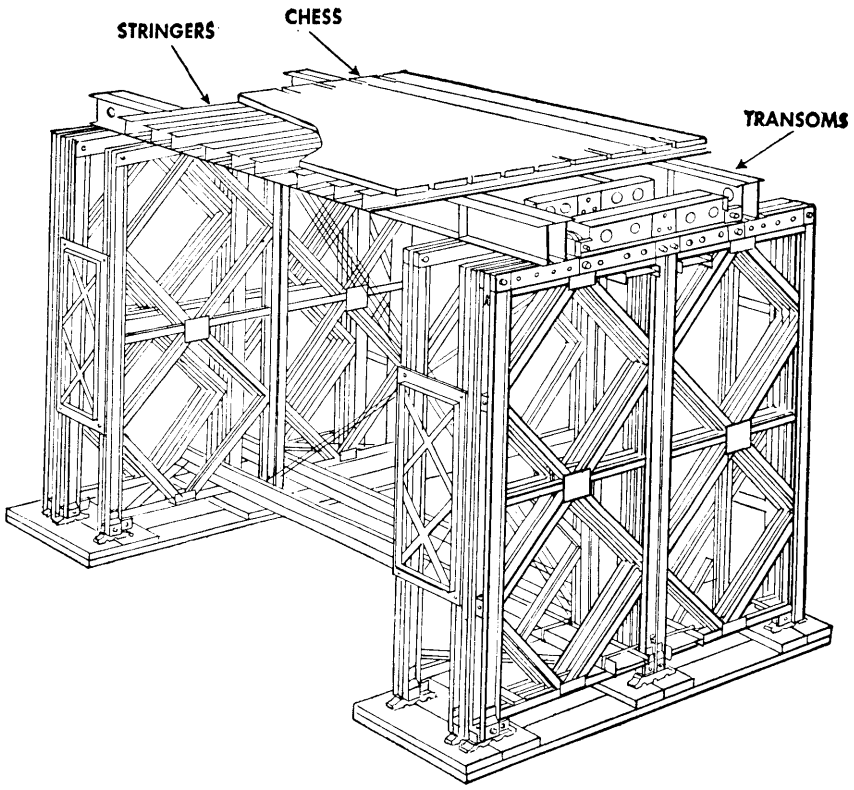


Figure 266. Temporary working platform made of transoms, stringers, and chess on top of panel crib pier.

CHAPTER 26

BRIDGES ON BARGES

Section I. GENERAL

229. Introduction

This chapter describes the construction and maintenance of the panel bridge on barges. The panel bridge on barges consists of a standard panel bridge supported on floating piers made from river or coastal barges of suitable type and capacity (fig. 267). Special spans or parts are used to provide hinged joints between floating bays.

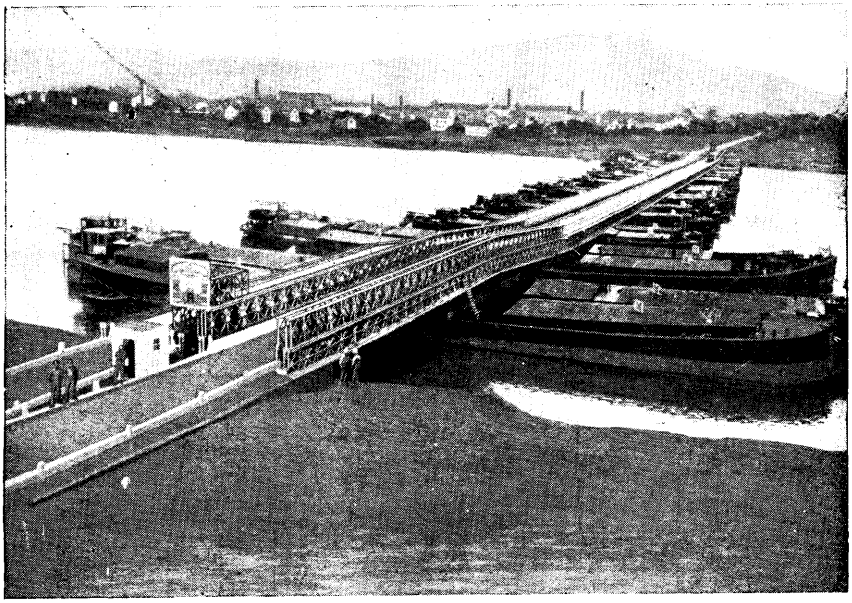


Figure 267. Panel bridge on barges across Rhine river.

230. Terminology (fig. 268)

a. PIERS. Piers consist of barges or vessels suitably prepared to support the panel-bridge superstructure.

(1) *Floating-bay piers.* Floating-bay piers support the floating bays in the interior of the bridge.

(2) *Landing-bay piers.* Landing-bay piers support the shore end of the floating bay and the riverward end of either the fixed-slope landing bay or the variable-slope landing bay.

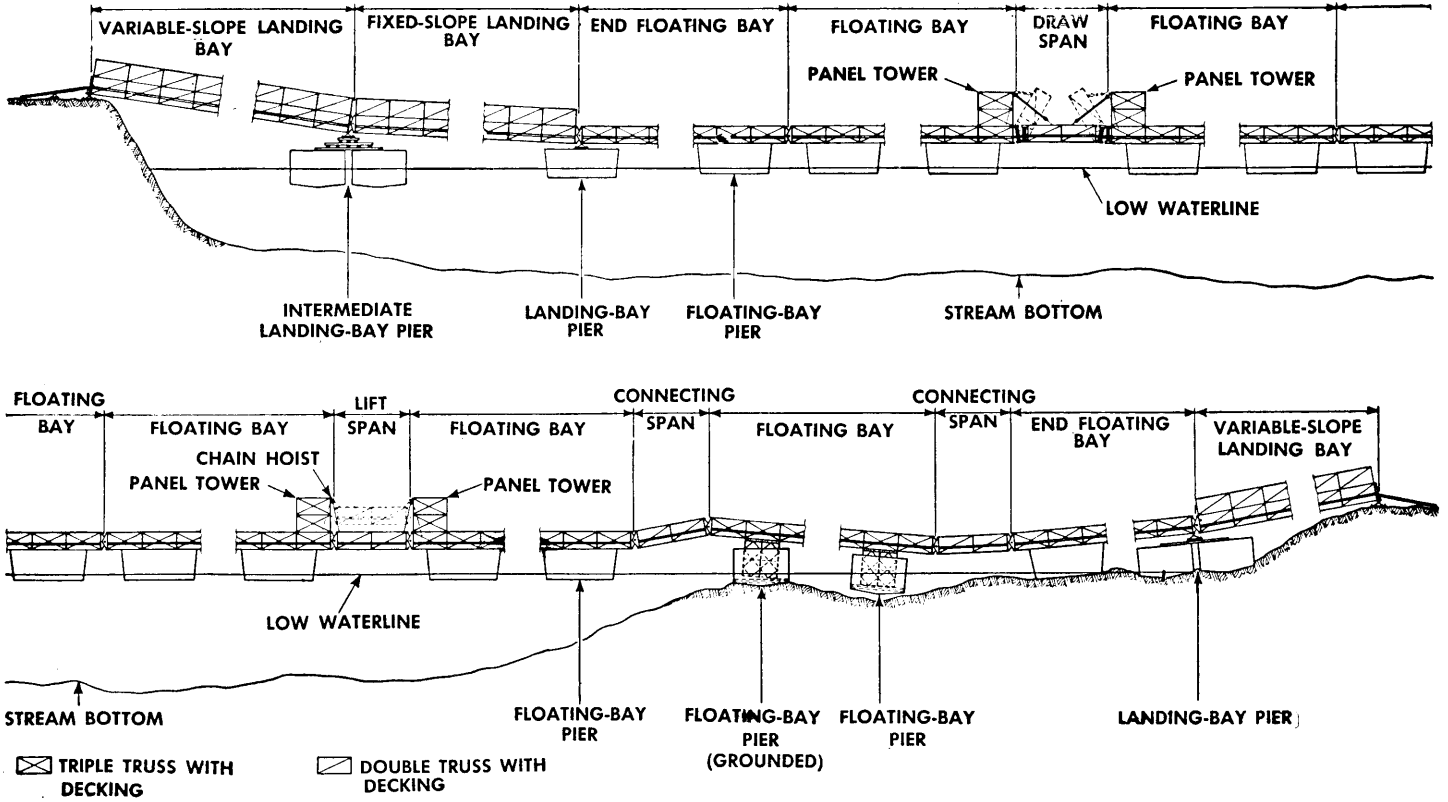


Figure 268. Nomenclature of panel bridge on barges.

(3) *Intermediate landing-bay piers.* Intermediate landing-bay piers support the shore end of the fixed-slope landing bay and the riverward end of the variable-slope landing bay. The intermediate landing-bay pier is not used without the fixed-slope landing bay.

b. BAYS. The span between two articulating points supported by two floating piers or between the shore and a floating pier is called a bay.

(1) *Floating bays* (fig. 269). Floating bays are the interior bays of the bridge from the end floating bay on the near shore to the end floating bay on the far shore. They are supported near each end by floating-bay piers.

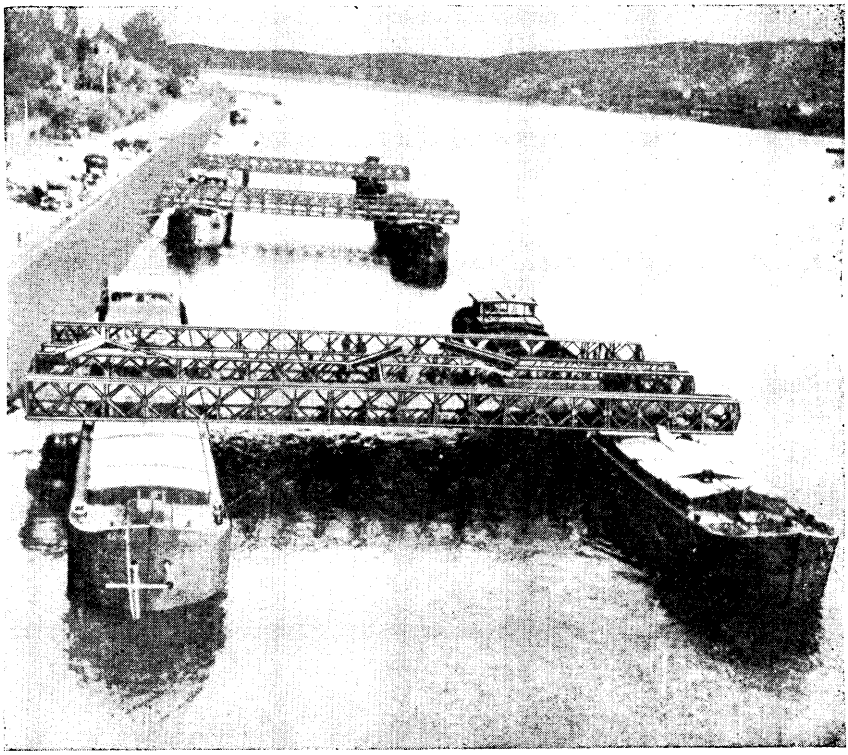


Figure 269. Floating bays.

(2) *End floating bays.* End floating bays form the continuation of the bridge between the floating bays and the landing bays. They are supported by a landing-bay pier and a floating-bay pier.

(3) *Landing bays* (fig. 270). Landing bays form the connection between the end floating bay and the bank. There are two types of landing bays—

(*a*) *Variable-slope landing bay.* The variable-slope landing bay spans the gap between the bankseat and the landing-bay pier or the intermediate landing-bay pier if a fixed slope landing bay is used.

(*b*) *Fixed-slope landing bay.* The fixed-slope landing bay spans the gap between the intermediate landing-bay pier and the landing-bay pier.

c. SPECIAL SPANS. (1) *Connecting span.* A connecting span connects two adjacent floating bays where barges are grounded. It provides two articulating points to compensate for the changes in slope between the floating bays (see par 231*b* (2) (*a*)).

(2) *Lift span* (fig. 271). A lift span connects two adjacent floating bays. The span can be lifted vertically by use of block and tackle or chain hoists to allow passage of water traffic through the bridge (see par. 231*b* (2) (*b*)).

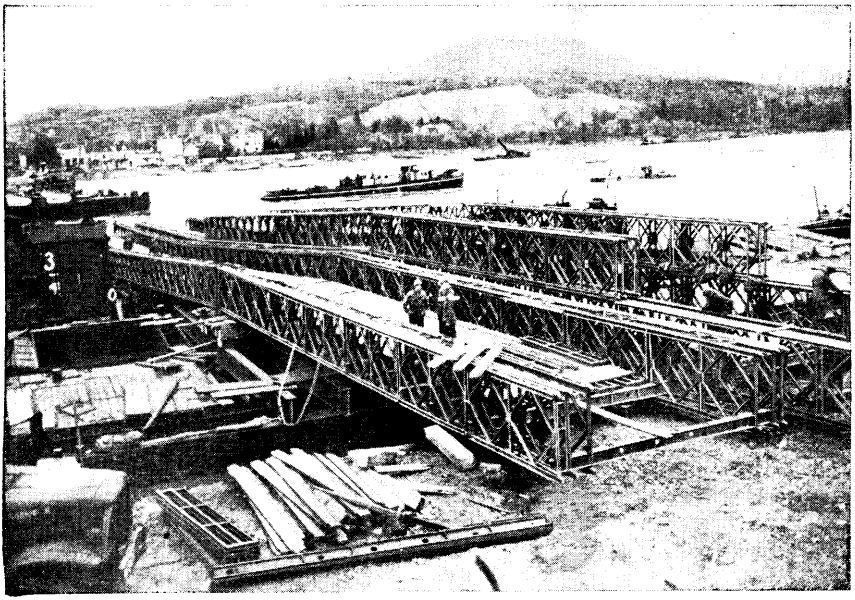


Figure 270. Landing bays.

(3) *Draw span* (fig. 280). A wider gap between adjacent floating bays for passage of river traffic can be obtained by use of a draw span. The draw span can be split in the middle and each half pivoted up (see par. 231*b* (2) (*c*)).

231. General Design and Capacities

a. BARGES. (1) *Description.* Coastal and river barges differ widely in construction and capacity throughout the world. In Europe and the Americas, barges are generally flat-bottomed. Barges with round or semi-round keels are also found on European canals and rivers (fig. 272). Asiatic barges have less capacity than European or American barges.

(2) *Capacity.* The capacity of a barge equals the weight of the volume of water displaced between the unloaded and loaded waterlines. Generally, European and American barges have a capacity of from 80 to 600 tons. The general condition and soundness of the barge has a direct effect on its use in a bridge.

(*a*) *Ribs.* Structural ribs of barges are designed for bending stresses induced by water pressure on the outside of the hull. They are normally bulb-angled steel sections 5½ to 7 inches deep, closely spaced, and curved rather than straight. Ribs should not be loaded as struts unless they are braced and the load is distributed. To distribute the load, timber cribbing

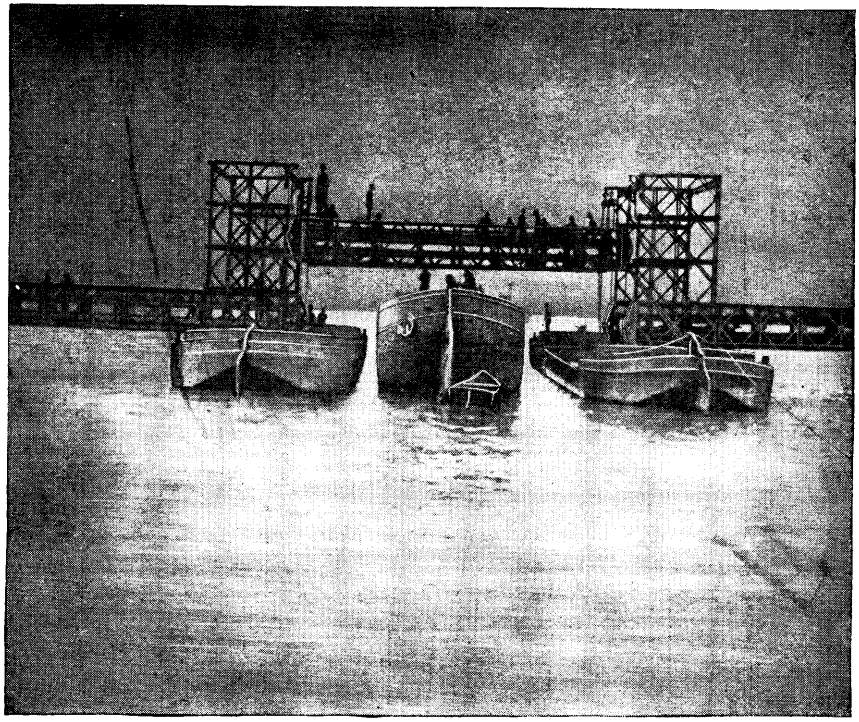


Figure 271. Panel-bridge lift span.

can be used along the gunwale directly over the ribs. If the rib is not curved and length of rib from deck to keel does not exceed 10 feet, each rib will support approximately 5 tons.

(*b*) *Floor.* Barge floors are designed for distributed loads. A wide variation of floor designs exists and care must be taken in estimating their capacity. European flat-bottomed barges normally use transverse beams of Z section 6 to 7 inches deep, carrying light channels or I-beams fore and aft to support a timber floor. A floor of this type can carry a bearing pressure of 0.5 ton per square foot (fig. 273).

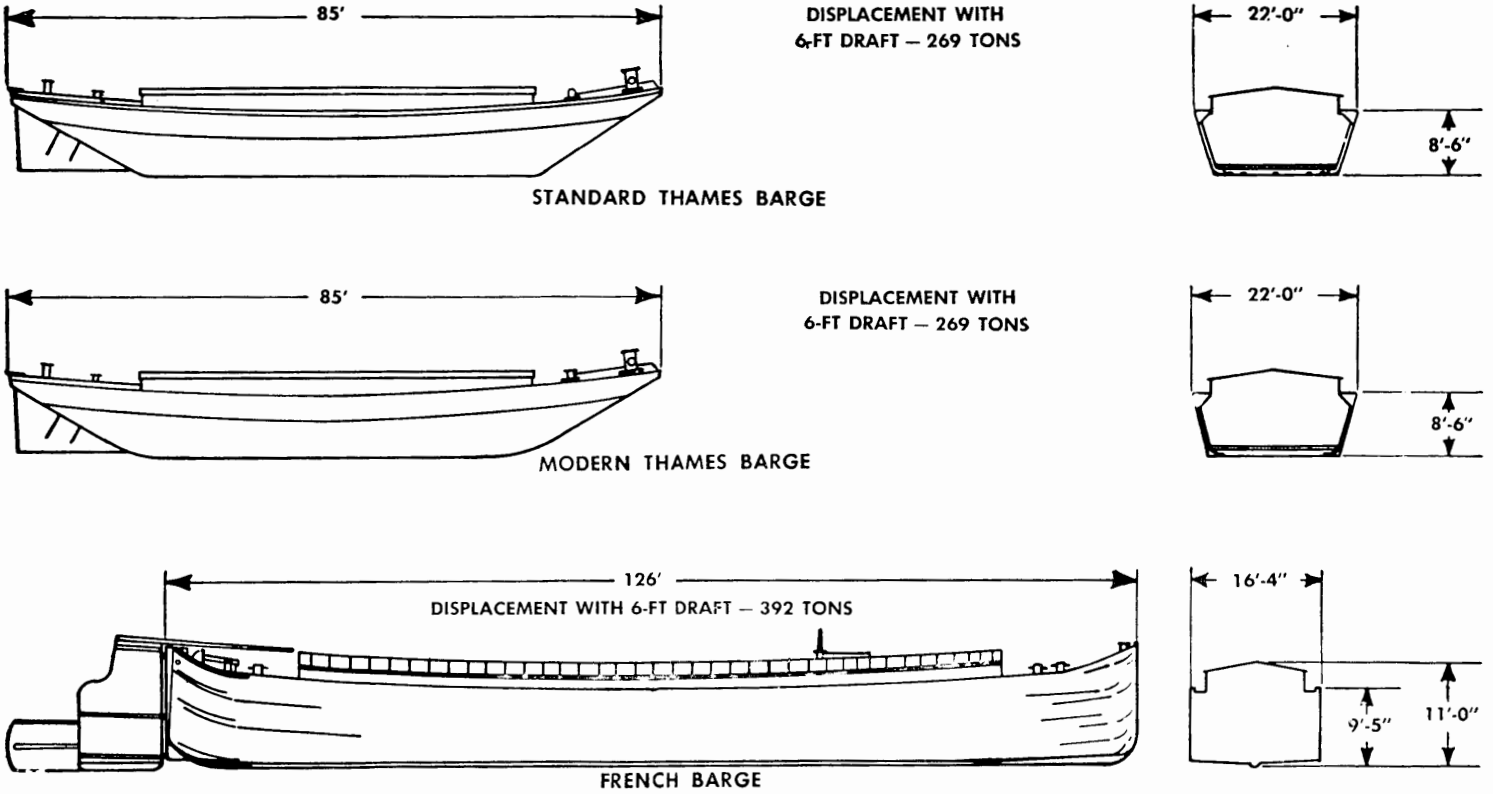


Figure 272. Typical European barges.

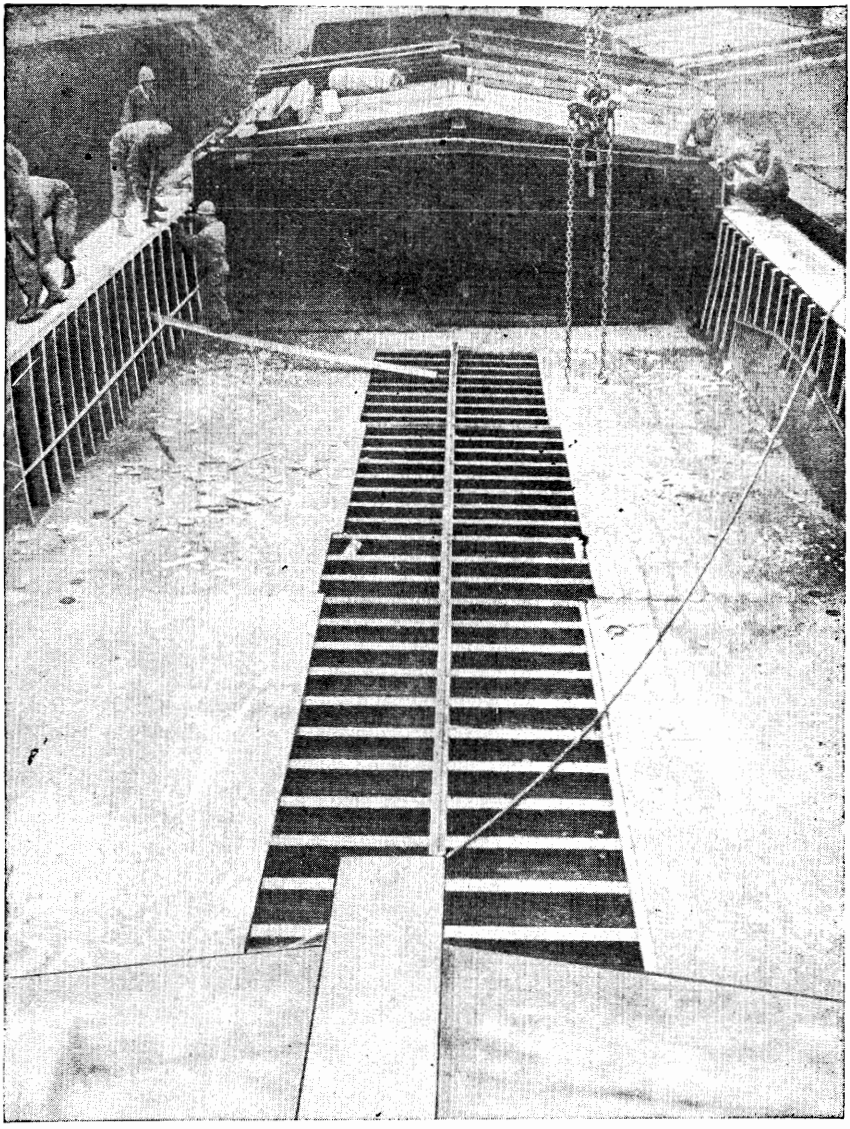


Figure 273. Typical European barge floor.

b. SUPERSTRUCTURE. (1) *Normal construction.* Superstructures of normal bays consist of DS, TS, DD, or TD construction of standard panel-bridge equipment. Normally, floating-bay superstructure is single-story construction and landing-bay superstructure double-story construction.

(*a*) *Decking.* Decking for superstructure consists of standard chess with 3-inch wear treads laid diagonally over the chess. Angle irons are added to deck on landing bay to increase traction (fig. 274). When special

connecting posts are used to connect floating bays, transoms and junction chess cannot be used to fill the gap between bays. Cut stringers are placed on the two transoms at the end of each bay (fig. 275) and two thicknesses of 3- by 12-inch planks spiked together are placed on top of the cut stringers (fig. 276). Planks are wired in place to prevent shifting. When span junction posts are used to connect bays, the gap between bays is filled in the normal manner, using transoms and junction chess. Where maximum road width is desired, ribands can be eliminated and a 2- by 24-inch hub guard installed 6 inches above the deck to protect the panels.

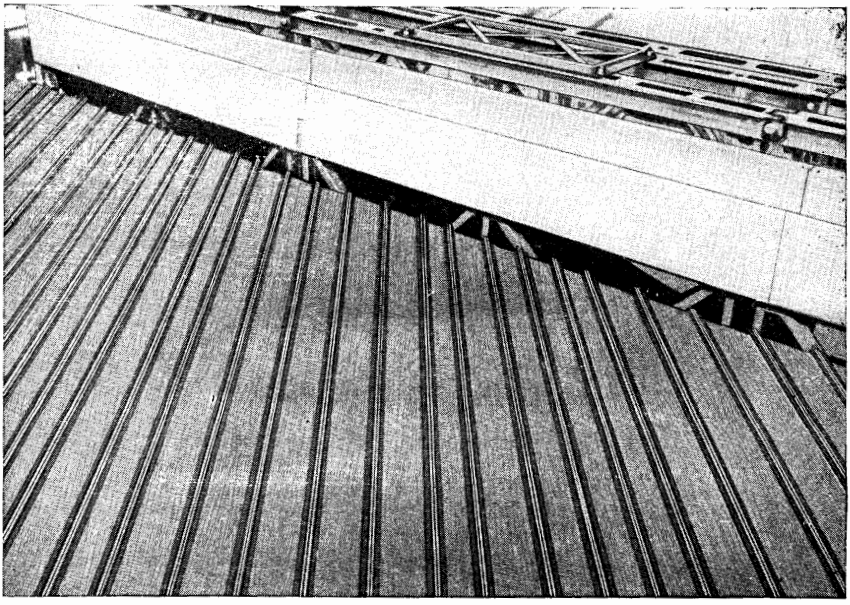


Figure 274. Angle irons and 3-inch diagonal decking used on landing-bay deck to increase traction.

(*b*) *Connections.* Special connecting posts are used to connect the bays together and provide articulation (fig. 277). These special connecting posts provide ample strength and allow development of full capacity of superstructure. Equal articulation above and below the connecting pin provides unrestricted space for movement in the connection. Such connectors do not require restrictive linkages, guides, or maintenance. Combination special connecting posts can be used in place of the normal posts and in addition can be used to connect two male ends of panels or two female ends of panels.

(2) *Special construction.* Special spans are used when barges are grounded or when passage of water traffic through the bridge is necessary. The capacities of the special spans are the same as the normal spans. However, their full capacity cannot be developed unless the suspending connection at each end is made strong enough. In addition, the weight of the lift span and draw span is limited by the lifting power and strength of the hoists, thus affecting the type of construction that can be used in these spans. The three types of special spans used are connecting spans, lift spans, and draw spans.

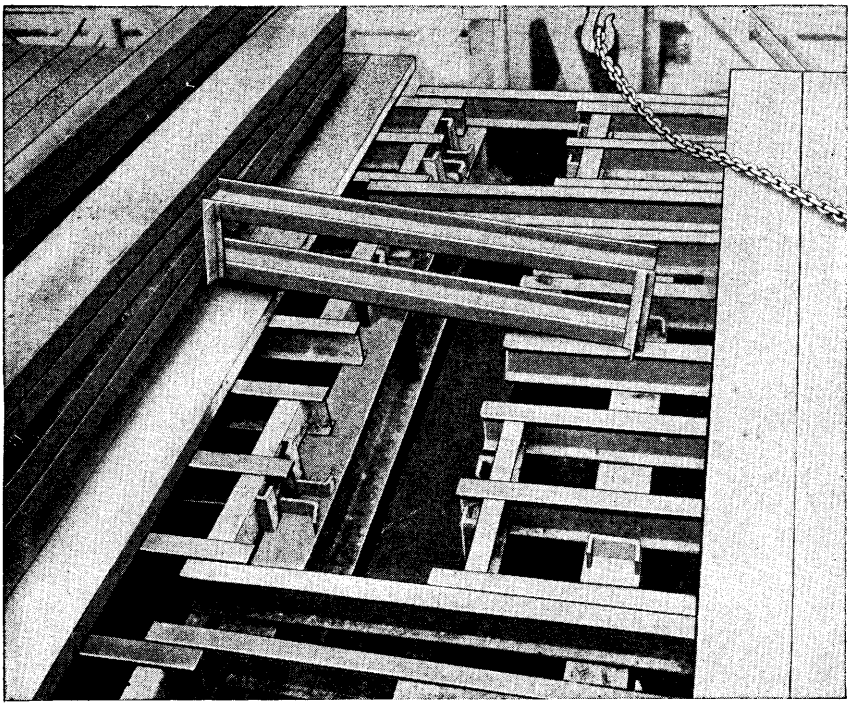


Figure 275. Cut stringers for filling gap between bays when bays are connected with special connecting posts.

(*a*) *Connecting span.* The connecting span is used when barges are grounded or when special connecting posts are not used. It consists of a short span of SS or DS construction suspended between two floating bays by span junction posts (fig. 278). Capacities of connecting spans are given in table 70.

(*b*) *Lift span.* Lift spans can be used only in short bridges where the current is slow and there are no longitudinal forces in the bridge (fig. 279). When the current is swift, the pier heights can be increased to arch bridge enough to pass water traffic under one of the center spans

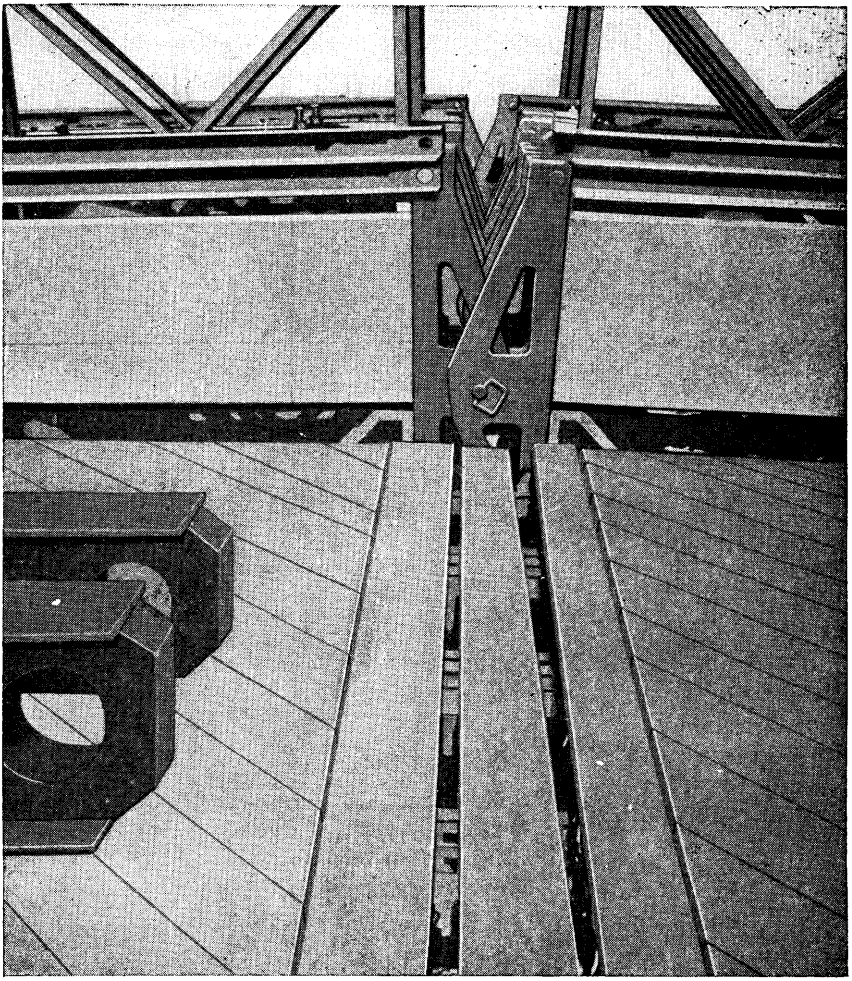


Figure 276. Planks on cut stringers for filling gap between bays when bays are connected with special connecting posts. Note hub guards and special connecting posts.

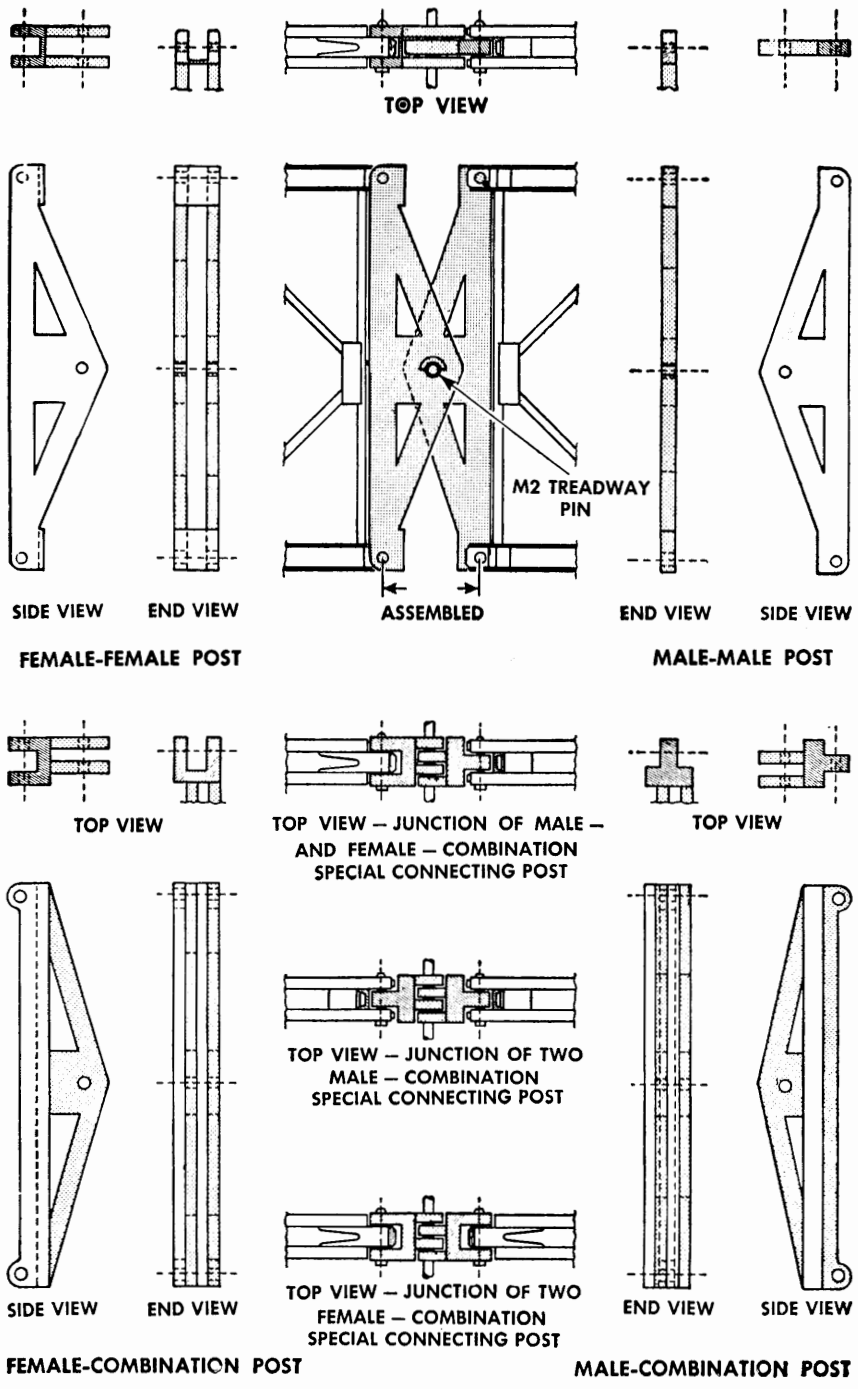


Figure 277. Special connecting posts.



Figure 278. Use of span junction posts to suspend connecting span between bridge bays.

without the use of a lift span. The lift span is SS or DS construction 20 or 30 feet long. It is raised horizontally by block and tackle attached to the span and to panel towers in the adjacent bays (fig. 271). Capacities of lift spans are given in table 70.

(*c*) *Draw span.* The use and the restrictions of the draw span are the same as for the lift span. The draw span is SS or DS construction usually 20 feet long (fig. 280). It is hinged and suspended to adjacent bays by span junction posts. It is raised at one end by block and tackle attached to the span and a panel tower in one of the adjacent bays. If the resulting gap is insufficient, a span of 40 feet can be used and a cut made at the center of the span. Towers with block and tackle are then used at both ends and each half lifted separately. Capacities of draw spans are given in table 70.

c. BAYS. The barges and the superstructure together form sections called bays.

(1) *Floating bays* (fig. 269). Floating bays are normally double-single construction. However, for loads of 100 tons or more, unsupported span lengths are limited to 60 feet and construction must be triple-single. The capacity is limited by the type of construction, the span between centers of barges, and the method used to support the superstructure on the barges. The capacity of floating bays is given in table 70. Normally, a barge near each end of a bay supports the superstructure. The superstructure must not overhang the barge at each end more than 15 feet from the centerline of the barge. However, a single barge can be used if it has ample width and capacity and the bay is stable under the load.



Figure 279. Lift span in bridge over Meuse River at Liege, Belgium.

(2) *Landing bays* (fig. 270). The type of construction used in landing bays depends on length of span and loads to be carried. Triple-double construction is heaviest used. Maximum slope of bay is 10 to 1 with adequate traction devices provided (fig. 274); without traction devices, slope is 20 to 1. Length of landing bay depends on conditions near shore. Double landing bays are used where considerable change in water level is expected or when high banks are encountered. Landing bays are assembled the same as normal panel bridges and use the same type of end support. Landing-bay capacities are given in table 70.

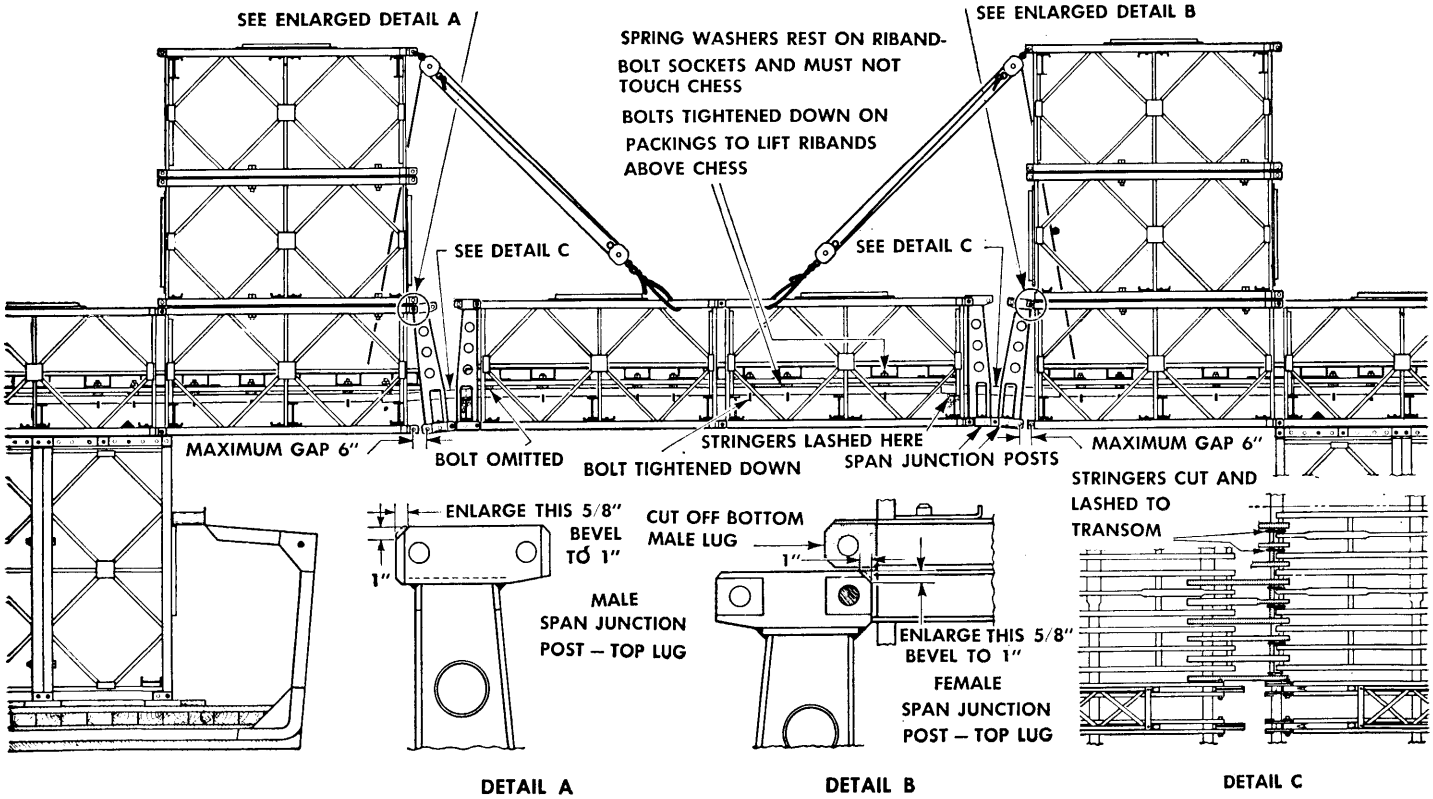
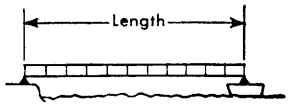
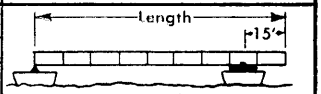
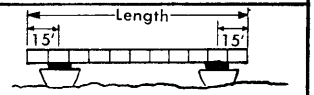
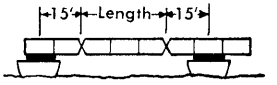
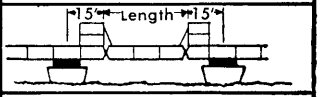
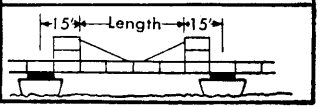


Figure 280. Panel-bridge draw span.

Table 70. Capacity of Bays and Spans in Panel Bridge on Barges

Type of bay or span	Truss construction	Length of bay or span (feet)														Illustration
		20	30	40	50	60	70	80	90	100	110	120	130	140	150	
Landing bay	SS		40	32	28	26	22	18	13	10						
	DS		107	93	80	67	64	51	44	31	23	18	13	10		
	TS				113	100	88	80	62	52	40	34	23	18	13	
	DD							103	90	75	64	50	40	31	23	
	TD								106	93	80	70	57	48	40	
	DT										106	93	80	67	65	
	TT													105	93	
End floating bay	SS				36	30	26	22	18	15	11					
	DS				100	86	73	62	52	44	35	27	20	15	11	
	TS						106	94	81	68	56	45	35	27	20	
Floating bay	SS					40	32	28	24	20	17	13	10			
	DS					107	93	80	67	57	48	40	31	23	18	
	TS							113	100	88	75	62	50	40	31	
Connecting span	SS	28	24													
	DS	80	67													
	TS	113	100													
Lift span	SS	28	24													
	DS	80	67													
	TS	113	100													
Draw span	SS	28	24	20												
	DS	80	67	57												
	TS	113	100	88												

232. Personnel Required

The wide variation in terrain conditions and flotation units prohibits the assumption of any given work method. However, it is suggested that construction of large bridges of this type be assigned to at least an engineer general service regiment or an engineer combat group. Section IV, this chapter, gives details of working-party organization.

233. Advantages and Disadvantages

a. ADVANTAGES. The panel bridge on barges has the following advantages:

(1) It does not use standard floats and pontons which may be needed at other sites.

(2) It allows long landing floating bays for use in tidal estuaries or rivers with high banks.

(3) It has large capacity barges which allow greater bridge capacity than standard military floating supports.

(4) It provides a stable bridge in swift currents.

(5) It minimizes hazards of floating debris and ice.

b. DISADVANTAGES. The bridge has the following disadvantages:

(1) It uses barges which may be difficult to obtain.

(2) It can be used only in navigable streams or waterways used by barges or vessels of the type and size necessary for use in the piers.

(3) It is not adaptable in combat areas because of equipment, material, labor, and time requirements.

Section II. EQUIPMENT

234. Barges

a. GENERAL. Barges are procured locally and should be processed in the following manner:

(1) Examine and rate for capacity.

(2) Determine the most advantageous point for use in the bridge.

(3) Establish the type of barge loading (sec. V) to be used and sketch necessary construction to bring bearings to exact elevation established for superstructure bearings.

b. SUPPORTS ON BARGES. After the type of barge loading has been determined, a material estimate and equipment requirement list should be prepared for each barge. Normally, steel beams, timber, blocking, wire rope, and miscellaneous bolts and fittings will be required. See chapter 25 for equipment required if panel crib piers are used as supports on the barges.

235. Superstructure

a. NORMAL SPANS. Normal spans use fixed-span panel-bridge parts

(chs. 5 and 6). Connections between spans are made with special connecting posts that must be fabricated in the field (fig. 277) or by connecting spans using span junction posts supplied in the panel crib pier set (ch. 25).

b. SPECIAL SPANS. Special spans use fixed panel-bridge parts (chs. 5 and 6) plus the additional parts noted below.

(1) *Lift span.* Special fittings to guide the lift span during raising and lowering must be made in the field. Block and tackle required are supplied in the fixed-panel-bridge set. Counterweights to aid in raising and lowering the span can be improvised. The lift span and the floating bays are connected by span junction posts.

(2) *Draw span.* Special fittings to guide the draw span during raising and lowering must be made in the field. Block and tackles required are supplied in the fixed-panel-bridge set. Counterweights to aid in raising and lowering the span can be improvised. The draw span and the floating bays are connected by span junction posts from the panel-crib-pier set ch. 25).

c. ERECTION EQUIPMENT. The normal erection equipment supplied in the fixed-panel-bridge set (chs. 5 and 6) is sufficient to build the superstructure. Truck cranes aid the erection of the superstructure and the preparation of the barges. The equipment of an engineer general service regiment is required and this should be supplemented with acetylene torches, arc welders, chain falls, power and hand winches, diving equipment, and sea mules or power tugs with enough power to move floating bays into position.

Section III. SELECTION AND PREPARATION OF SITE

236. Site Characteristics

Tactical requirements determine the general area within which a site must be selected. The following factors should be carefully considered in choosing the actual site:

a. ROAD NET. There should be a road net close to the site over which equipment can be moved. Roads and approaches should require as little preparation and construction as possible and should be straight and level for at least 150 feet before reaching the stream bank.

b. NEAR-SHORE AREA. Near-shore area should afford suitable sites along shore for barge preparation and bay assembly.

c. BANKS. Banks should be reasonably steep and firm so that water gap will not change materially with water level. Banks high enough to allow launching of superstructure to barge piers are desirable.

d. STREAM. The site should be on a straight reach of the stream or estuary and free from cross currents that would exert a longitudinal

force on the bridge. Water at bridge site should be deep enough to float barges at low water if no barges are to be grounded. Water at assembly sites should be deep enough to allow preparation of barges close to shore and launching of superstructure directly to barges. If barges can be grounded at low water, stream bottom should be reasonably smooth and level. The stream should be free of obstructions at the assembly sites and bridge site.

237. Reconnaissance

The general area having been determined by tactical requirements, a study of terrain and aerial maps is made to determine possible bridge sites along the stream within the specified area.

a. AIR. Direct aerial reconnaissance generally obtains the following information on these bridge sites:

(1) Site relation to existing road net with estimate of road construction required.

(2) Alinement of river at site and channel obstructions in the vicinity.

(3) An approximation of height of banks to determine suitability for approaches and landing bays.

(4) Approximate width, shore to shore, of river and length of bridge required.

(5) Location, relative to bridge site, of material storage, equipment and work areas, and barge sites adjacent to near shore for floating-bay assembly.

(6) Location of barges large enough to be examined later in detail by ground reconnaissance.

(7) Nature of open water route from barges to bridge site, noting and locating obstructions to navigation.

(8) Routes over existing road nets for transportation of bridge materials from dump or other sources to bridge site.

(9) Location of adjacent quarries and aggregate supplies.

b. GROUND. Ground reconnaissance obtains the following data:

(1) Width of river from bank to bank.

(2) Profile of approaches and stream bed.

(3) Character of soil in approaches, banks, and stream bed,

(4) Profiles of possible routes of approach and linking roads to existing road nets.

(5) Current velocity.

(6) High and low water datum indicated on profile and rate of flood and ebb of tide, if possible.

(7) Sketch showing location and description of suitable material

storage and work areas, downstream assembly area with profiles at possible shore barge preparation sites, and floating-span erection sites.

(8) Sketch of barges located in aerial reconnaissance.

(9) Routing on open water from assembly sites to bridge site with description and location of obstacles and estimate of work necessary to clear passage.

(10) Information on location, quality, and quantity of nearest aggregate source.

238. Lay-out and Preparation of Site

Before actual construction, alinement and grade of roads and approaches must be determined. Storage and assembly areas are planned and located in such a manner as to insure an uninterrupted progression of the work and to avoid unnecessary handling. After the location and lay-out of the site has been determined, road work and approaches should be completed to expedite delivery of bridge material. At the same time, landing-bay and floating-bay assembly areas are prepared. For more detailed information, see chapter 10.

Section IV. WORKING PARTIES

239. General

An engineer group or regiment consisting of three battalions, two panel bridge transport companies, one light equipment company, and one harbor craft company should be assigned to construct bridges of 500 feet or more. For shorter bridges, reductions in personnel can be made.

240. Distribution of Personnel

The following table presents a suggested break-down of jobs and troops required for constructing an 810-foot class 70 bridge in a moderate current. Approach road construction will require 5 company-days.

Job	*Personnel*
Abutment preparation	1 platoon
Landing-bay construction	3 platoons (per bank)
Floating-bay construction	2 platoons (per site)
Movement and connection of bays	1 platoon
Unloading of equipment	1 platoon
Anchorage preparation	1 platoon

Assume bridge will consist of the following bays, proceeding from near to far bank: 100-foot DD variable-slope landing bay; 100-foot DD fixed-slope landing bay; 80-foot TS end floating bay; 40-foot DS draw span; three 100-foot TS floating bays; 90-foot TS end floating bay; and 100-

foot DD landing bay. A possible assignment of units to construct this bridge is as follows: one battalion to construct two near-bank landing bays, 80-foot end floating bay, and one floating bay; the second battalion to construct far-bank landing bay, 90-foot end floating bay, 40-foot draw span, and two floating bays; the third battalion to prepare approach roads, unload equipment, and prepare anchorages; the panel transport companies to haul bridge equipment; the harbor craft company to assist in maneuvering barges and bays; and the light equipment company to supply construction equipment with operators. Time required for completion is approximately 6 days of daylight construction.

Section V. CONSTRUCTION OF BRIDGE

241. Barges

Care must be taken in selection of barges. Structural condition, capacity, shape, freeboard, type, and location of barge must all be considered.

a. PRELIMINARY WORK. (1) Barges located on the reconnaissance should be examined and rated. Barges which meet the requirements should be assigned a position in the bridge. Working sketches and a plan of preparation for each barge are necessary to adapt it for use as a floating pier.

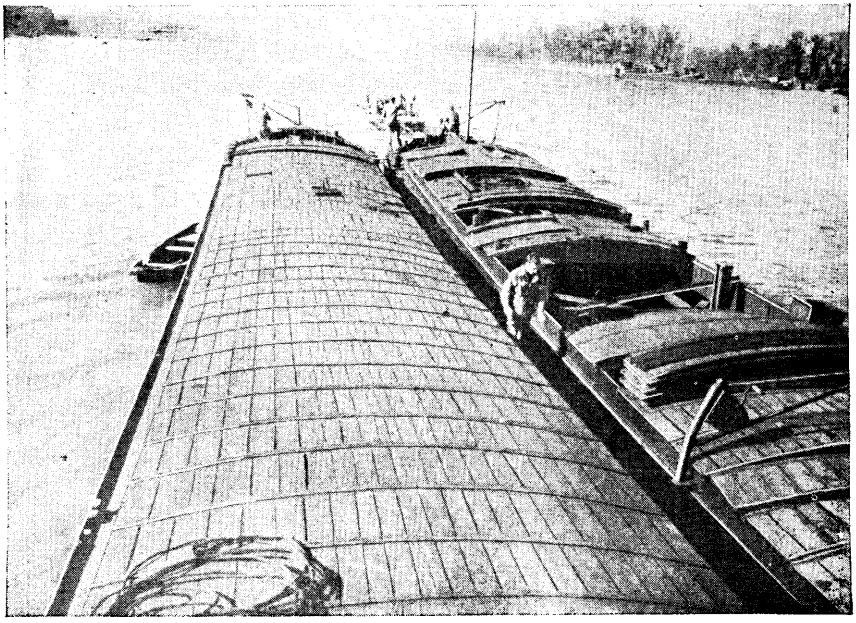


Figure 281. Towing barges to barge preparation sites.

(2) Nonusable, easily unloaded material should be cleared from the selected barges to facilitate towing to barge preparation sites (fig. 281).

b. METHODS OF LOADING. Barges are adapted for use as piers by three methods. The method employed depends on the type of barge — flat-bottomed or keeled — and grounding conditions. The three methods of loading are as follows:

(1) *Gunwale loading.* (*a*) *General.* Few barges are designed for gunwale loading and it is necessary to determine the strength of the barge ribs before this method is used. Barges are normally built with a narrow deck running full length along each side of the hold. This deck space can be used for gunwale loading if the ribs and the deck are strong enough and the load is applied as nearly as possible over the ribs (fig. 282). Gunwale loading must not be applied to barges that will ground at low water unless the barge and the bay will remain level. If keel type barges are used, the site of grounding should be in soft mud. Flat-bottomed barges should ground on flat sandy bed free from obstructions.

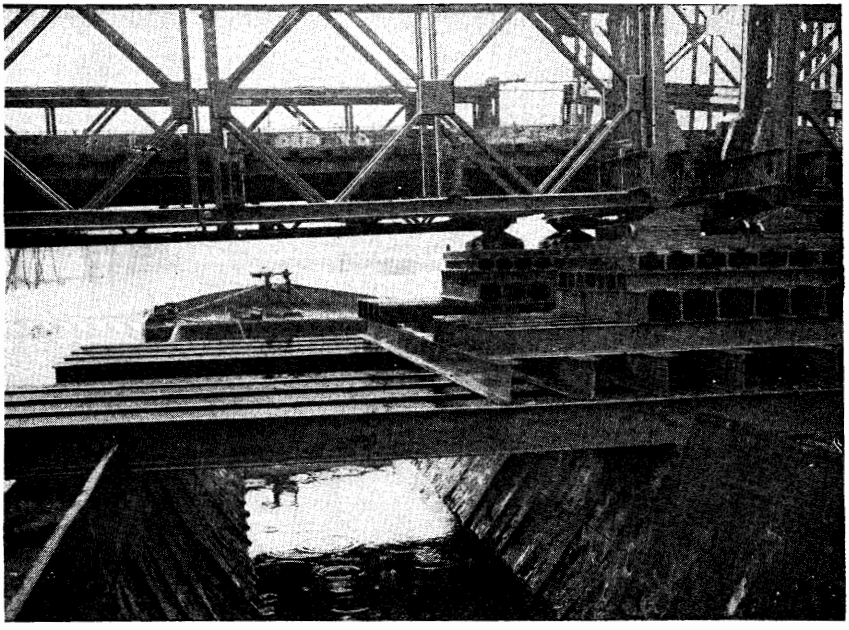


Figure 282. Gunwale loading of barges.

(*b*) *Methods of adaption.* Packing must be used between the gunwale and the superstructure to distribute the load. The deck is normally cantilevered from the ribs and considerable load is placed on the ribs when the deck is loaded. It probably will be necessary to support the deck by struts from the barge floor to the edge of the deck or by packing the gunwales. The load on the gunwale can also be reduced by using

a reinforcing bent built up from the floor in the center of the barge (fig. 283). Barges with curved ribs must be braced by rods between the gunwales or by struts from the reinforcing bent (fig. 284). If ribs are not curved and the length of rib from deck to keel does not exceed 10 feet, reinforcing of ribs is not necessary.

(2) *Crib loading.* Cribs made of panel crib parts (ch. 25) can be used to support the superstructure on the barge if the barge is unsuitable for gunwale loading or uneven grounding occurs. Barge floors are

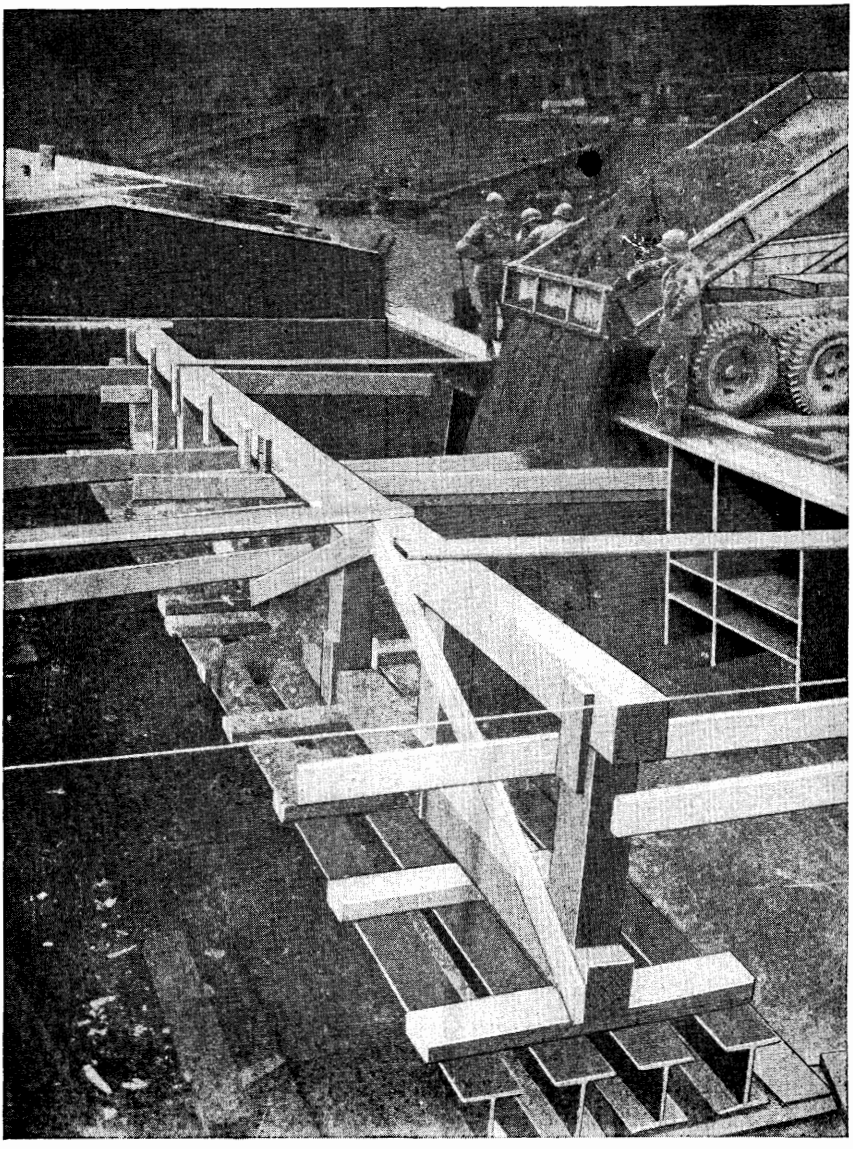


Figure 283. Reinforcing bent for reducing load on gunwale.

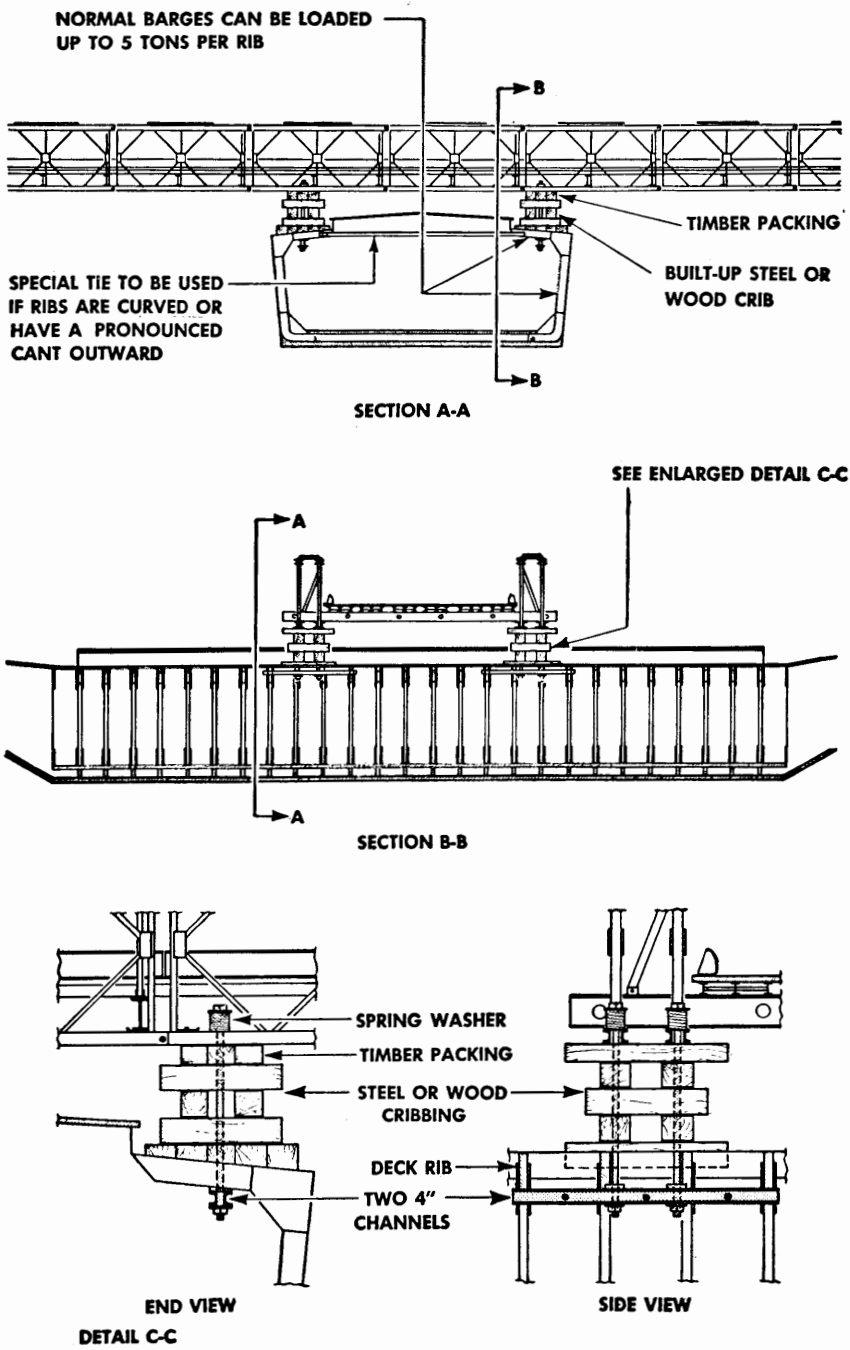


Figure 284. Adapting barges for gunwale loading.

designed to carry distributed loads, and grillage must be used under the cribs to insure adequate distribution of the load. Crib loading requires more time for construction than gunwale loading but crib loading distributes the load to the floor of the barge, which is capable of carrying more load than the gunwales. It is essential to observe the behavior of cribs when the bridge is first loaded and during tidal changes. The position of bearings should be marked so that movements can be determined. If careful observations are made, adjustments can be made in time to prevent serious movements and avoid the difficulty of repositioning barges and correcting misalinement of superstructure. Secure anchorage of cribs will prevent most of this difficulty. The two types of cribs used are fixed and rocking.

(*a*) *Fixed cribs* (fig. 285). Fixed cribs are used in both flat-bottomed and keeled barges that do not ground during low water. They are also used in keeled barges that ground during low water to prevent the barge from tipping. Fixed cribs are rigidly connected to both the superstructure and the barge floor and guyed both laterally and longitudinally to the gunwale. Details of assembly and methods of attaching the cribs to the superstructure and the barge floor are similar to those given in chapter 25.

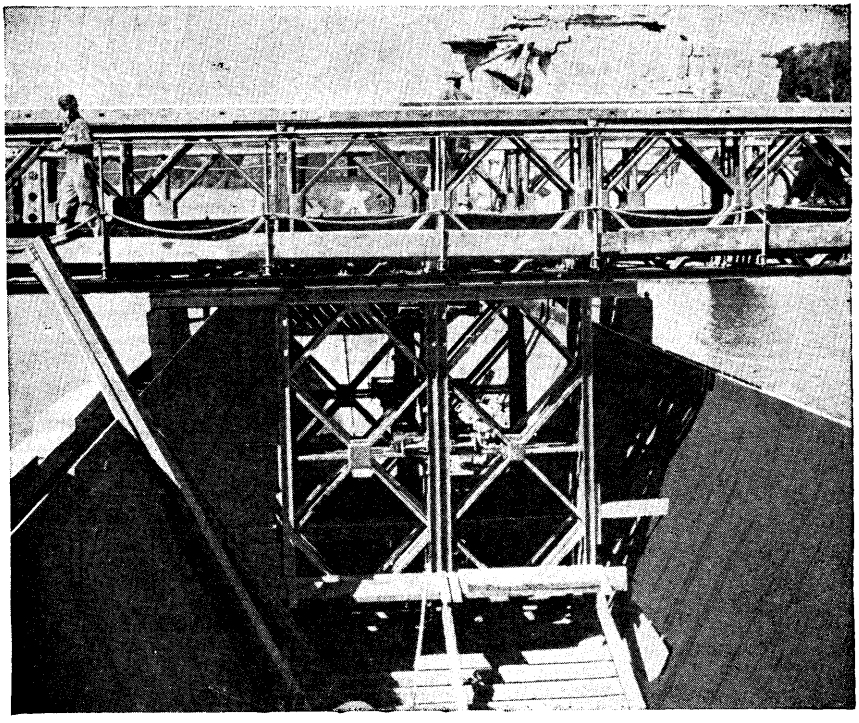
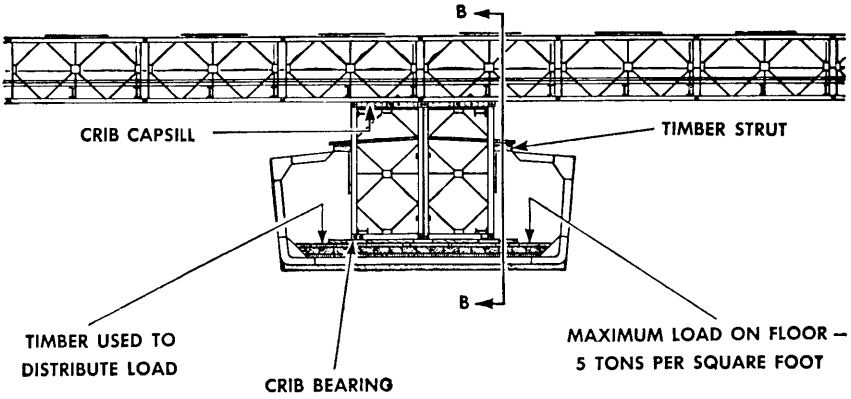
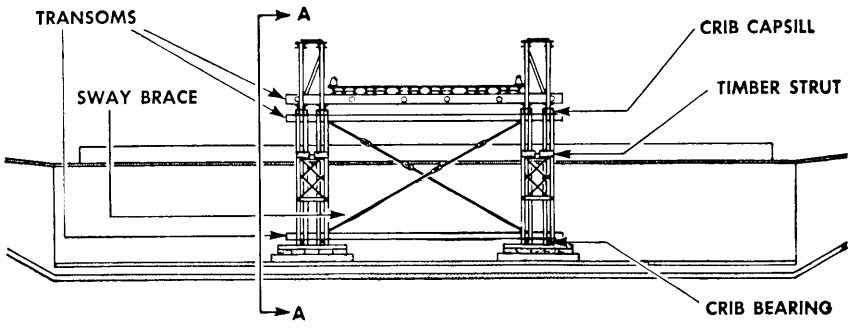


Figure 285. Fixed crib made from panel-crib-pier parts.

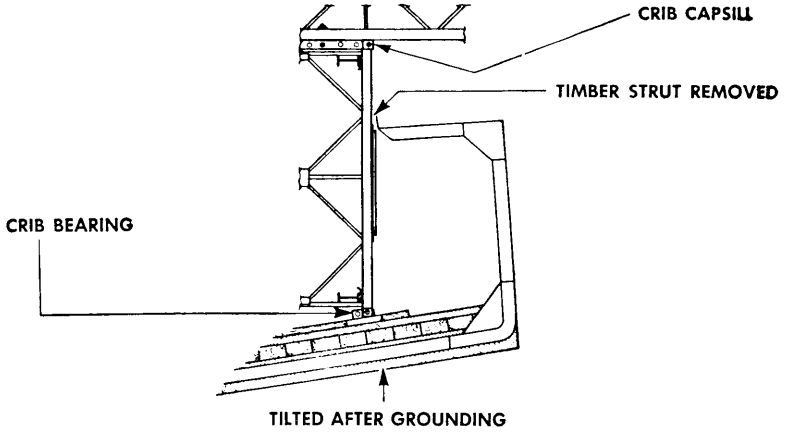


SECTION A-A



SECTION B-B

(1) FLOATING BARGE USING PANEL CRIBBING



(2) GROUNDED BARGE USING PANEL CRIBBING

Figure 286. Expedient rocking crib.

(*b*) *Rocking cribs.* Rocking cribs are used in flat-bottomed barges when uneven grounding occurs. Details of assembly and methods of making the rocking connections are given in chapter 25. Clearance between the crib and the gunwale must be enough to permit the full articulation required. The required clearance can be determined from the slope of the stream bottom where the grounding occurs. Rocking cribs are guyed fore and aft on the centerline of the barge as an additional safeguard against movement. An expedient rocking crib is shown in figure 286. The crib is made to rock by removing one of the panel pins in the crib bearing before the barge has grounded.

(3) *Grillage loading.* Grillage loading is used when the barge is unsuitable for gunwale loading and the panel-crib-pier parts are not available. Grillages are built up from the floor of the barge with steel or timber beams (fig. 287). When grillage loading is used, care should be taken in bracing and tying of grillage and to insure adequate distribution of the load on the floor of the barge.

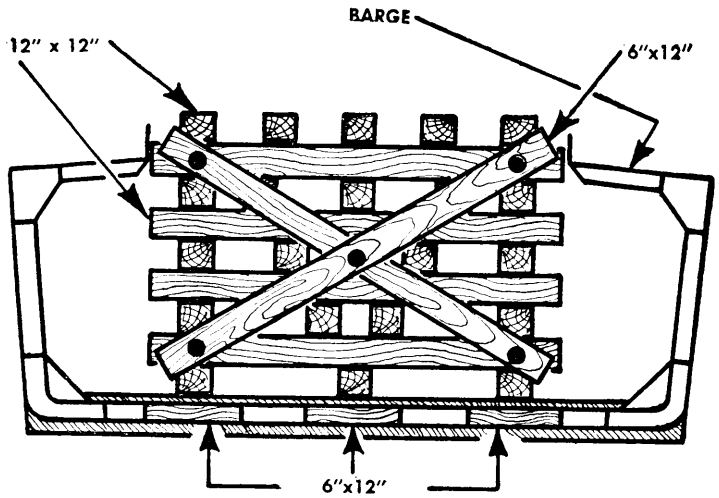


Figure 287. Section of timber grillage in barge.

242. Piers

a. LANDING-BAY PIERS. Both types of landing-bay piers are prepared in a similar manner. Since the intermediate landing-bay pier acts as a compensator in ramping, it always has a higher elevation than the landing-bay pier (fig. 268). Piers are built up to the required elevation using I-beams, bolted down or welded to prevent sliding (fig. 288). When special connecting posts are not used to connect landing bays, base plates are welded to the piers and standard bearings welded to the base plates to support end posts (fig. 282).

b. FLOATING-BAY PIERS. Floating-bay piers are prepared similar to

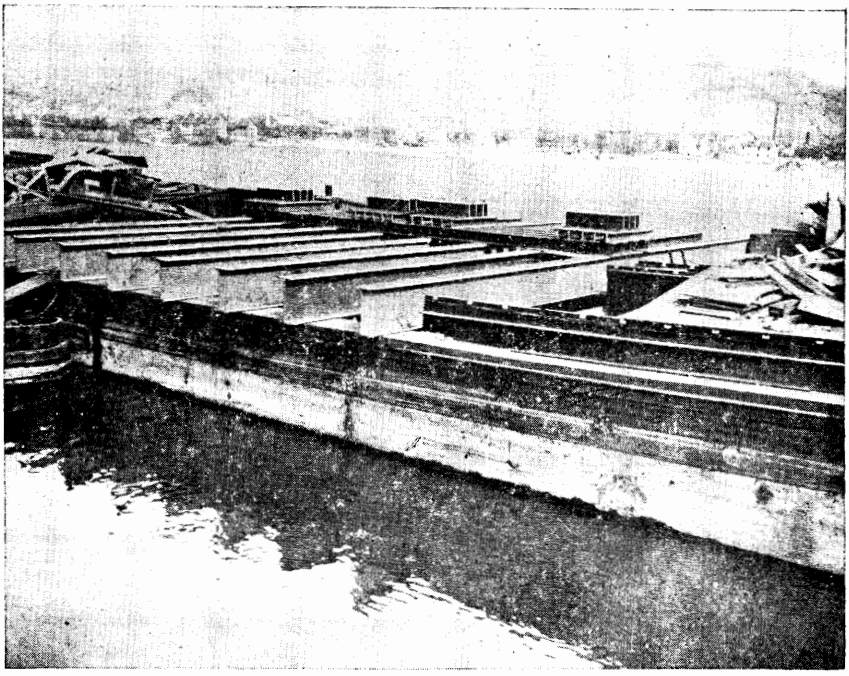


Figure 288. Preparation of intermediate landing-bay pier.

the landing-bay piers. Barges should be paired so those used in any pier have approximately the same freeboard (fig. 289). When the barges in the floating-bay piers have different freeboards, the superstructure seats must be cribbed up to the elevation of the superstructure seat on the barge with the greatest freeboard.

243. Bays

a. LANDING BAYS. (1) *Assembly.* Normal assembly methods given in chapter 12 are used for assembling landing bays.

(2) *Launching.* Several methods of launching landing bays can be used. Long spans are normally launched undecked.

(*a*) Where piers can be moved close to bank, landing bays are launched over rollers on bank to pier (fig. 290). The skeleton tail (ch. 28) method is used where bank conditions prevent moving barges in close.

(*b*) Where double landing bays are required, they can be launched as a continuous span, separately, or by use of construction barges.

1. The two bays are assembled as a continuous span on the centerline of bridge abutment. This span is launched over rollers placed on intermediate landing-bay pier onto cribbing on landing-bay pier. The top chord is broken over the intermediate pier by removing pins and then river end is jacked into final position. Bottom pins are removed and the variable-

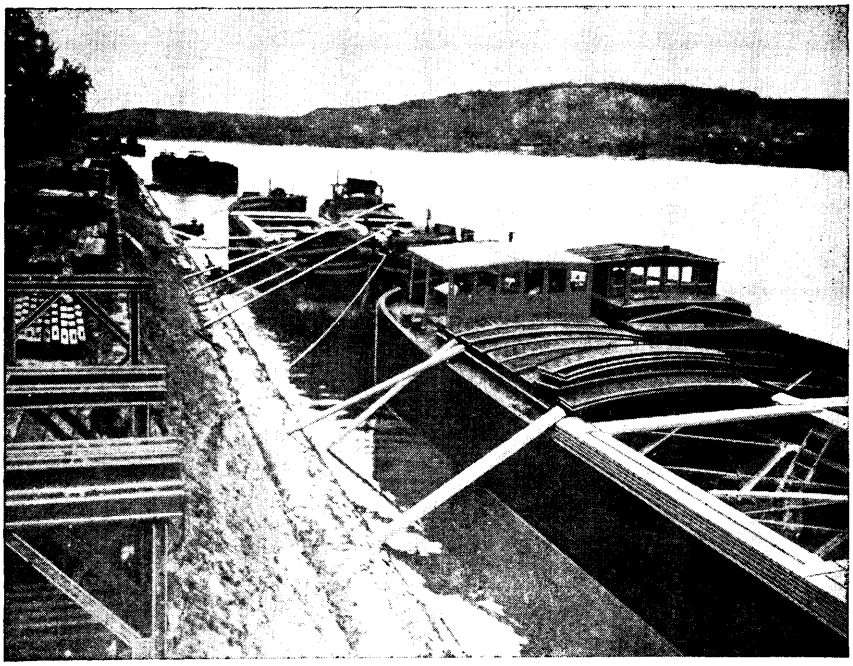


Figure 289. Paired barges for floating-bay piers.

slope bay is pulled back to permit installation of end fittings on intermediate pier for both bays. Abutment fittings are placed in usual manner.

2. When launching separately, the fixed-slope bay is launched as described in (*a*) above except rollers are placed on intermediate pier instead of bank. The variable-slope bay is then launched as described in (*a*) above.

3. The fixed-slope bay can be erected off site and launched to position on the intermediate floating-bay pier and a construction barge. The bay thus formed is floated into position and connected to the end floating bay. The construction barge is removed. The variable-slope bay is then launched as in (*a*) above.

b. FLOATING BAYS. (1) *Assembly.* Methods given in chapter 12 are used for assembling floating bays.

(2) *Launching.* Several methods of launching floating bays can be used.

(*a*) Where barges can be placed close to bank, the span is launched over rollers on bank (fig. 291) to off-bank barge, the barge is pushed out, permitting in-bank barge to be positioned. Span is then jacked down into place on in-bank barge. A construction barge can be placed adjacent to shore to use jacks on. This should have a lower freeboard than other barges.

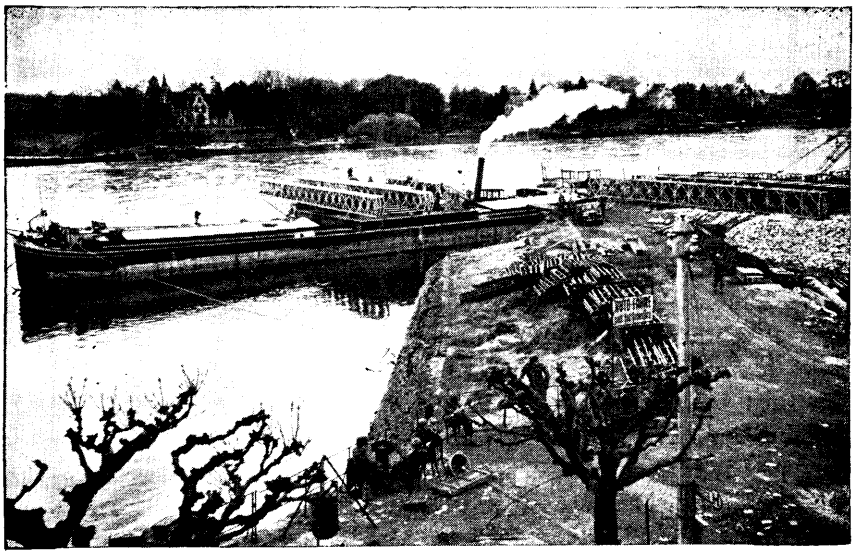


Figure 290. End floating bay prepared to receive landing bay.

(*b*) Where bank conditions permit, both barges can be moored side by side and span launched over rollers on in-bank barge to position on off-bank barge. The off-bank barge is pushed out until span is in position over in-bank barge and then span is jacked down into position on in-bank barge.

(*c*) When barges have wide beams, sections of bridge can be assembled on each barge and then joined to form bays; for long bays, surplus barges are partially flooded and floated from under the superstructure.



Figure 291. Double-single and triple-single floating-bay spans assembled on rollers on bank preparatory to launching onto barges.

(*d*) Cranes can place bridge equipment on barges, where it can be assembled on rollers (fig. 292). Barges are spread apart to obtain proper bay length as superstructure is assembled.

244. Connecting Bridge Sections

a. LANDING BAYS (1) *Special connecting posts.* The use of special connecting posts for connection of all bays is desirable. Articulation provided is normally ample under all conditions. When both a fixed-slope landing bay and a variable-slope landing bay are required, the special connecting posts on the river end of the variable-slope landing bays have bearing blocks welded to bottom. The posts are seated on bearings welded to base plates which are welded to the intermediate landing-bay-pier grillage (fig. 293). The shore end of the variable-slope landing bay is fixed with standard end posts mounted on bearings welded to base plates. The base plates rest on rollers set in an expedient box plate (fig. 294). This provides for lengthening and contraction of the bridge during changes in water level. The river and shore ends of the fixed-slope landing bay are suspended by treadway pins in the special connecting post (fig. 293).

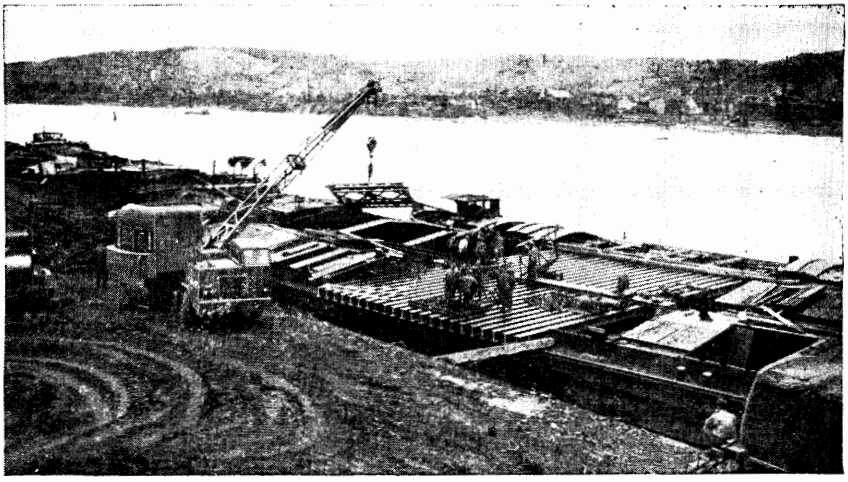


Figure 292. Assembling panel bridge on barge piers.

(2) *Standard end posts.* Where special connecting posts are not available for connecting landing bays, the bays can be seated on standard end posts on bearings. End posts on adjacent ends of variable-slope and fixed-slope landing bays should rest on bearings welded to base plates mounted on the intermediate landing bay pier grillage. The river end of the fixed-slope landing bay is seated on standard end post bearings resting on base plates welded to the end floating-bay pier.

The shore end of the variable-slope landing bay is mounted as described for special connection posts.

b. FLOATING BAYS. Connection of floating bays is made easier by carefully constructing each bay to the same elevation. A ballast of water can be loaded for adjusting freeboard of the bay. A vehicle on the bay to be connected can be moved to aid in alining connecting-pinholes.

(1) *Movement of bays for connection.* Considerable tug power is required to move and handle the bays into connecting position. The use of both towing and pusher tugs is necessary to provide adequate control of the bays to prevent damage (fig. 295). Floating bays over 100 feet long are difficult to tow and control.

(2) *Special connecting posts.* In connecting bays fitted with special connecting posts, it may be necessary to jack the truss into place to obtain sufficient pin-hole alinement for the treadway pin (fig. 296).

(3) *Connection articulation.* Maximum articulation and movement of junctions between bays during grounding should be carefully estimated. Excess articulation will result in undesirable changes of slope in the decking and may cause tilting or lifting of stringers or chess. If such a condition might develop at grounding, junction articulation can be minimized by use of a connecting span between the bays (par. 245).

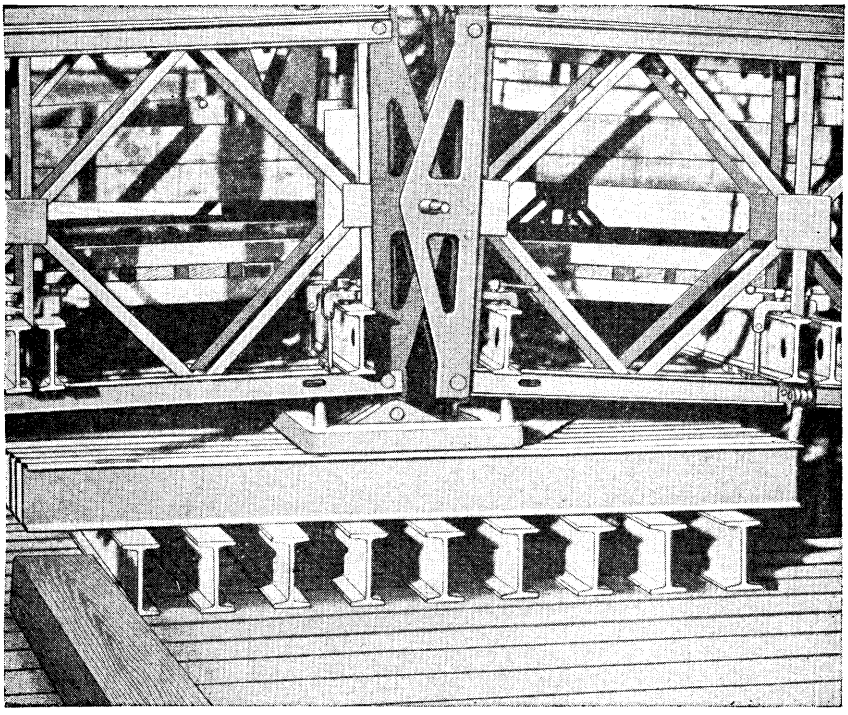


Figure 293. Bearing under special connecting post of variable landing bay.

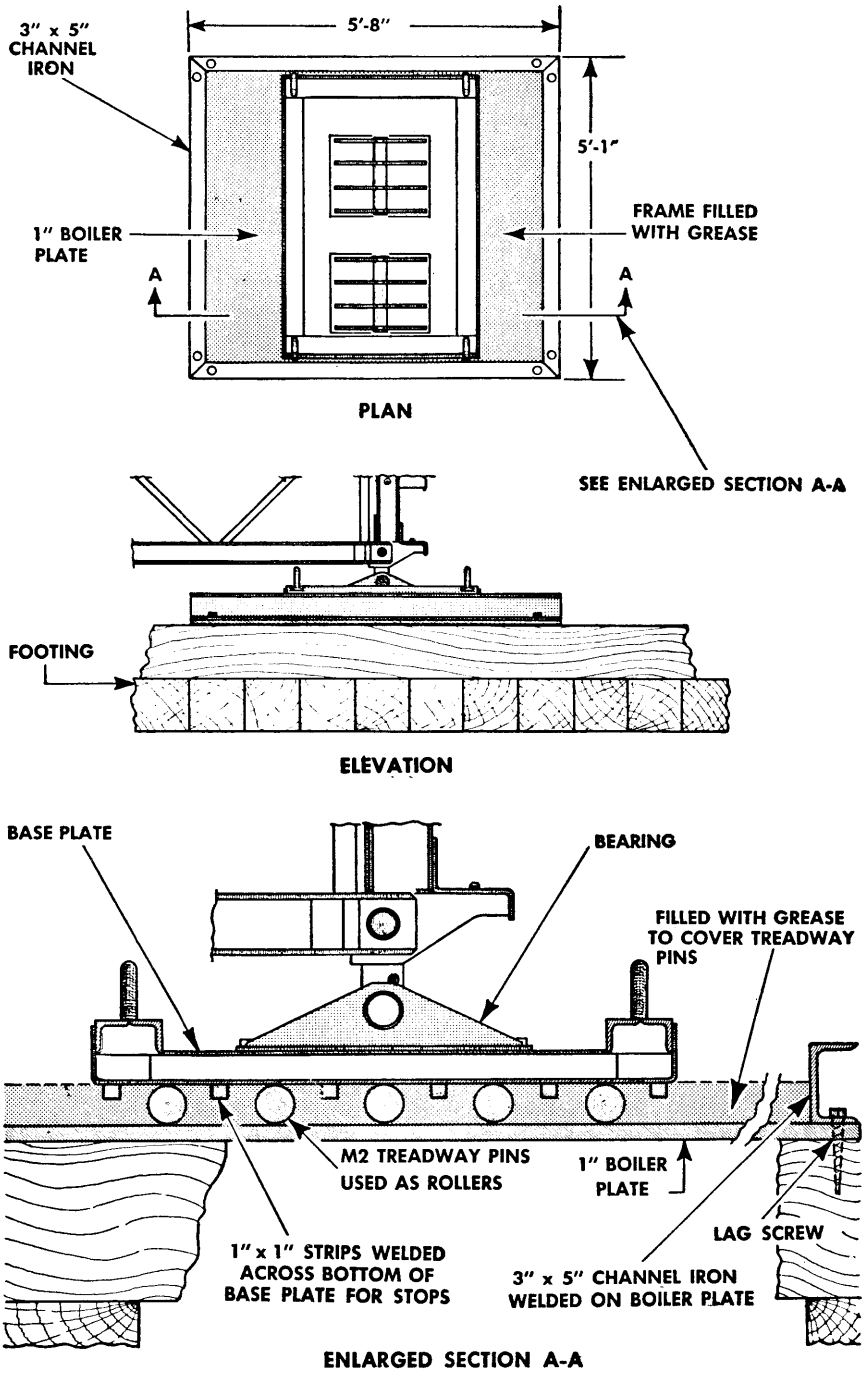


Figure 294. Shore sliding base plate in place.

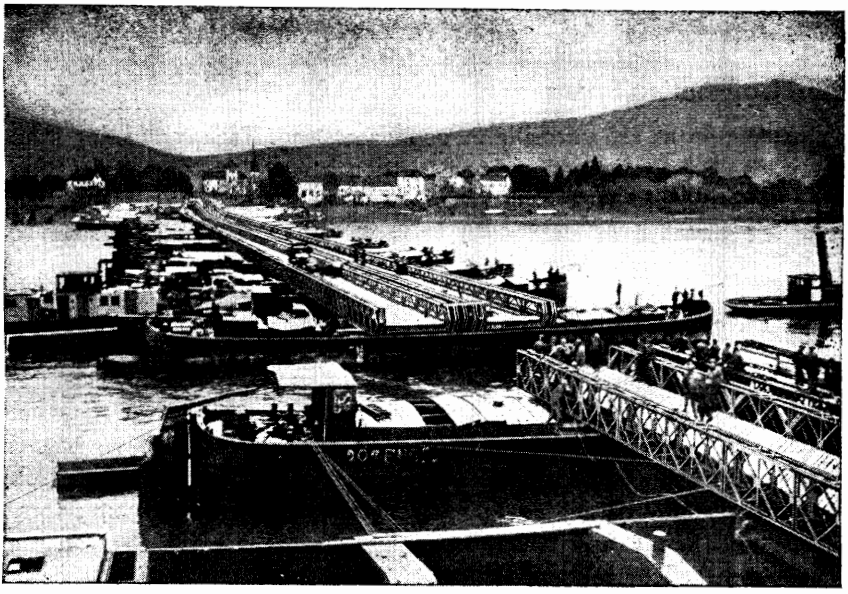


Figure 295. Towing and pusher tugs moving a 100-foot bay into position for connection.

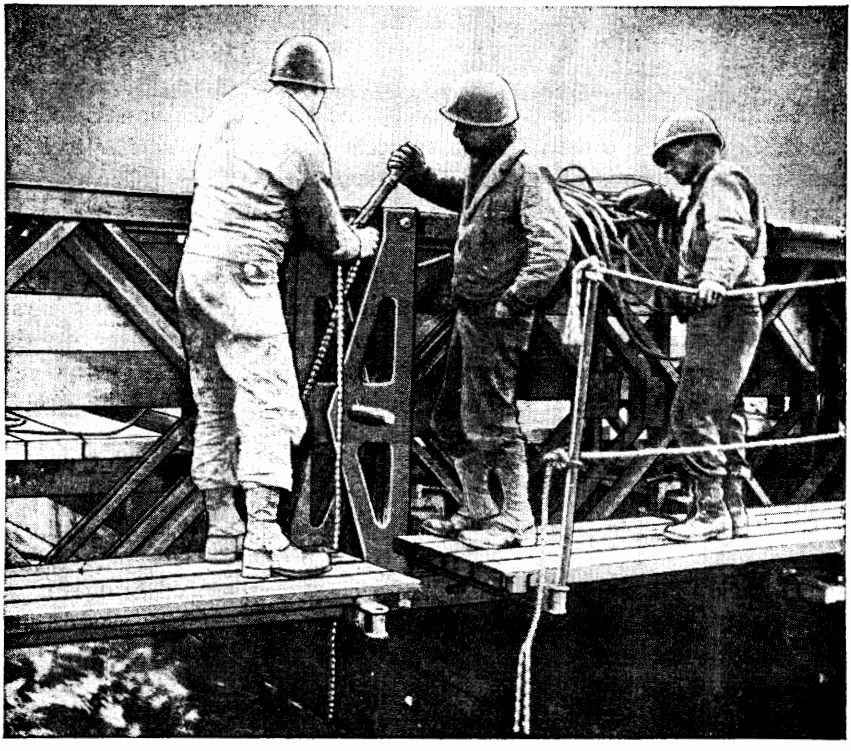


Figure 296. Connecting bays with special connecting posts. Jacking the truss.

Section VI. SPECIAL CONSTRUCTION

245. Connecting Spans

Connecting spans are normally 20 or 30 feet long. Each connecting span is erected directly on a single construction barge at a correct elevation for connection in the bridge. Appropriate male and female connecting posts are installed at span ends to connect and suspend the span to girders of the adjacent bays in the bridge (par. 248).

246. Lift Spans

The lift span is normally erected on a construction barge at a correct elevation for connection in the bridge. The length and lift of the span is determined by the beam and clearance of the vessels to be passed through the bridge. To lift the span, panel towers are constructed on the ends of the adjacent floating bays (fig. 279). Suitable connectors, guides, and lifting and counterbalancing devices are installed on the towers for the control and lifting of the lift span. Connecting posts are installed at the ends of the lift span and girders of adjacent floating bays for connection when span is lowered and in position to receive vehicular bridge traffic (fig. 297). Floating bays supporting the lift span must be designed to insure a level bridge.

247. Draw Spans

The length of the span is determined by the beam of the vessels to be passed. Towers are constructed on adjacent floating bays similar to lift span towers. Methods of constructing draw spans are as follows:

a. Draw spans can be erected on a construction barge to correct elevation, and then moved and connected into bridge.

b. One-half of the draw span can be added to the adjacent floating bay after tower erection at the bay construction site. The two floating bays can then be connected to bridge, and draw span can then be connected.

c. Draw spans can be constructed by assembly of single girders on the deck of adjacent spans. These girders can be launched by using tackle from towers to support free ends. The girders are pinned to bays and then decked.

248. Connecting Special Spans

a. Connecting Spans. When used to connect grounded bridge bays with special connecting posts, no special devices or maintenance will be required after the span is connected and suspended from girders of the adjacent bay ends.

b. Lift Spans. The lift span is connected to the supporting adjacent bays by special connecting posts or span junction posts when positioned

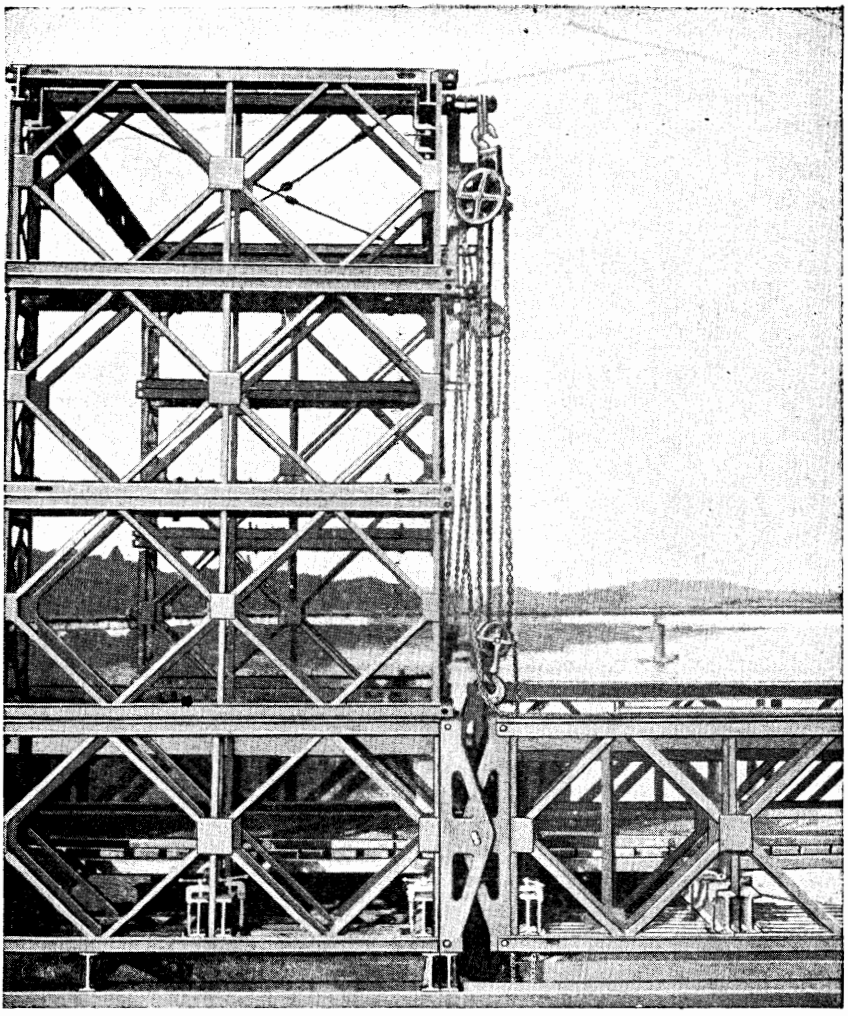


Figure 297. Panel tower and lift span connected and pinned for bridge traffic.

and pinned for vehicular bridge traffic. A vertical guide system should be provided on the tower to control the longitudinal movement of the span during the lifting of the span and insure proper pinhole alinement for reinsertion of connecting pins upon lowering (fig. 298).

c. DRAW SPAN. (1) A draw span is connected to its adjacent floating girders by means of a suspension link or hinge mechanism. The link consists of span junction posts.

(2) Decking must be arranged to allow for movement across junctions. Stringers are cut as shown in figure 280, one end being lashed down to the end transom of the draw span.

(3) The installation of a pair of span junction posts at the center of the draw span facilitates operation in forming the cut. The pins are

readily removed when the weight of the draw span is taken on the tower tackles. In lifting the draw span halves, one side is raised until the jaws are clear. The panels are then levered sideways, if required, to enable simultaneous raising of the span halves without fouling.

Section VII. ANCHORAGE

249. General

The bridge should be secured by anchors and guy lines against the effect of wind and current (fig. 299).

250. Anchors and Anchor Lines

a. ANCHORS. Types of anchors required can be determined from an examination of the stream bottom and computation of expected pull on anchor lines due to current and wind. Barges loaded with stone or metal can be sunk upstream of bridge to serve as anchors (fig. 300).

b. ANCHOR LINES. (1) Anchor line pull equals the sum of pull due to effect of current on submerged portion of barge and effect of wind on exposed portion of barge and superstructure. The following formulas may be used to determine this pull:

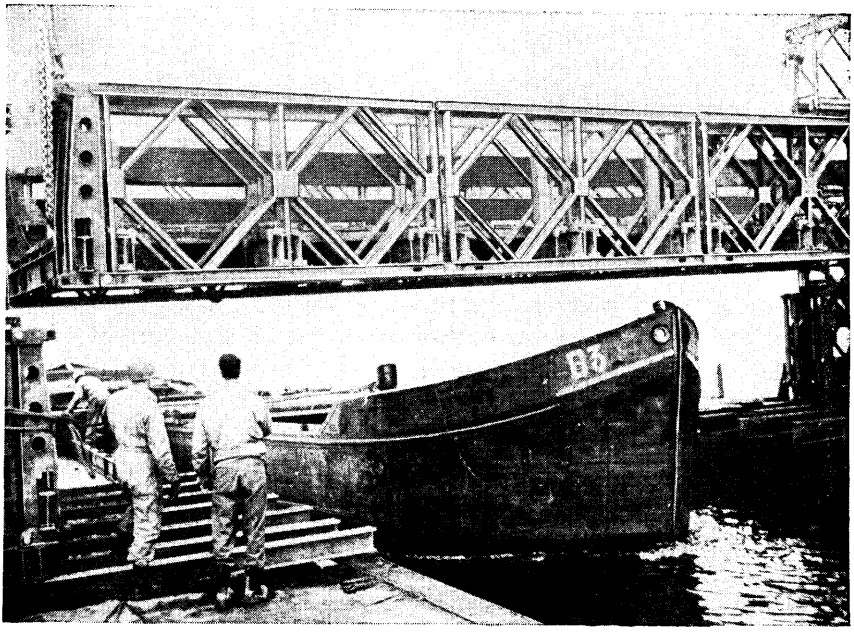
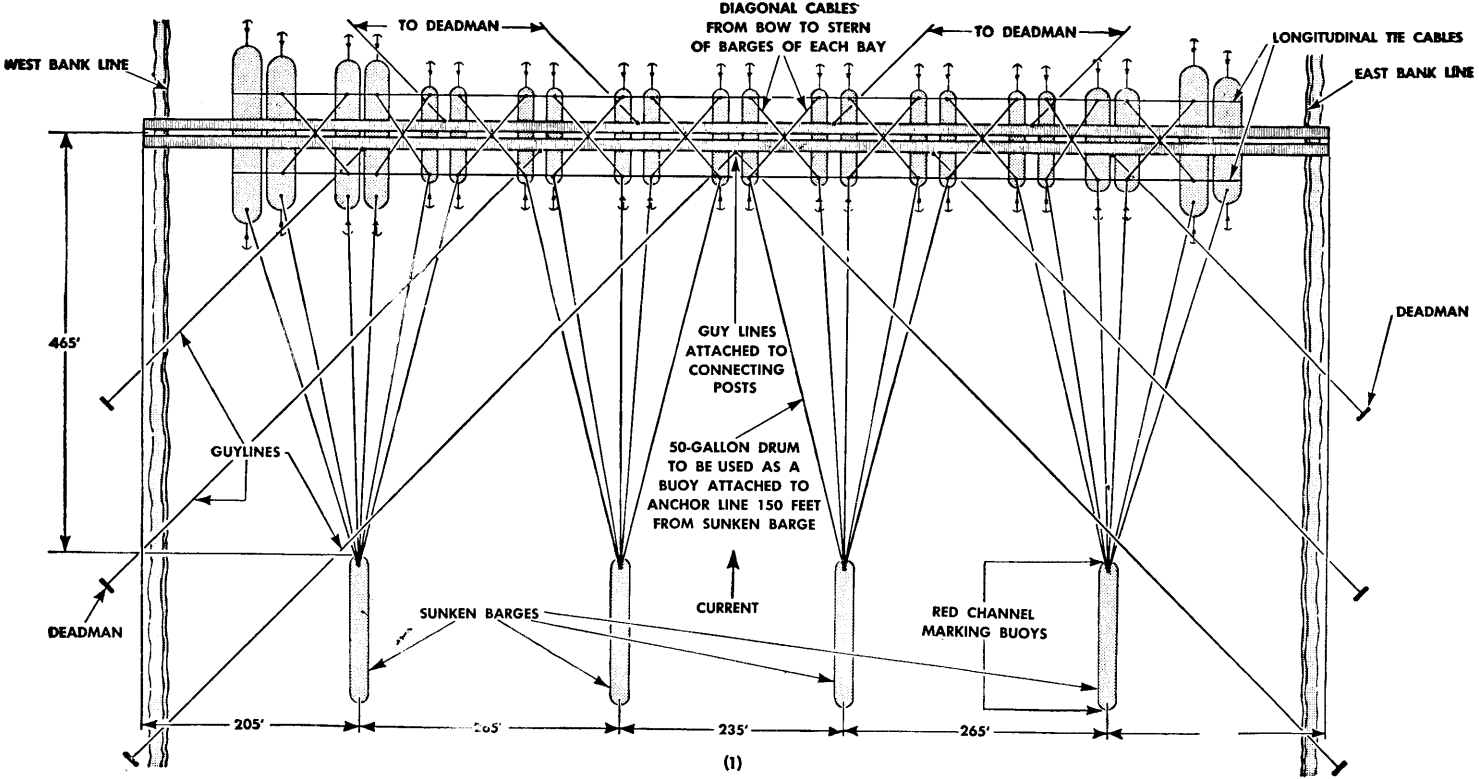
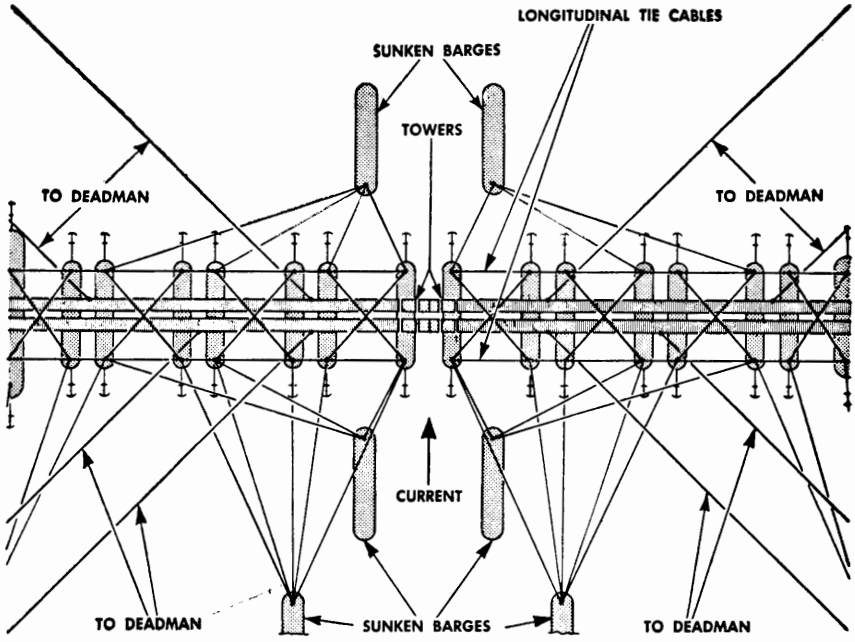


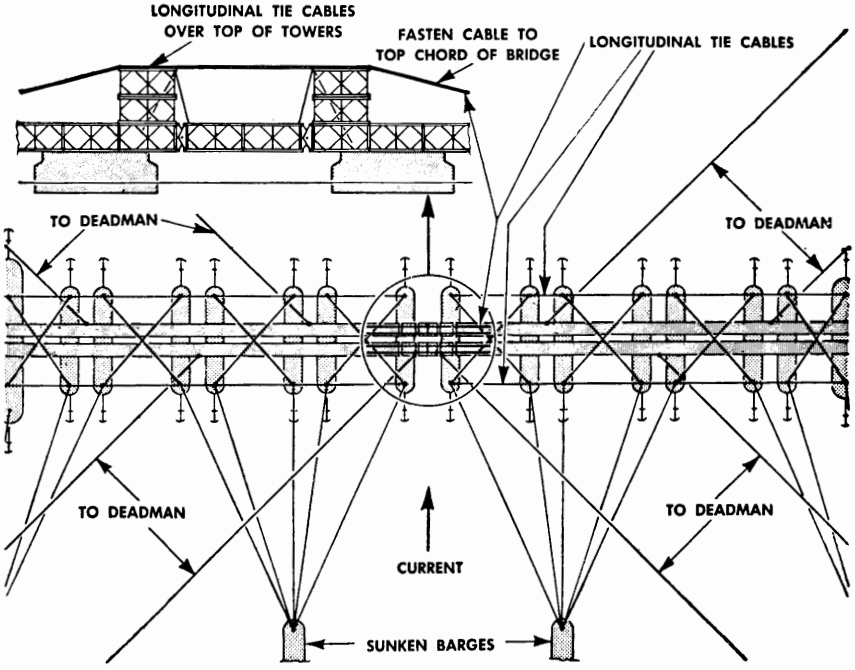
Figure 298. Lift span raised for river traffic. Note use of span junction posts.



(1) System used in barge bridge at Bad Godesburg, Germany
Figure 299. Anchor and guy line systems.



(2) DRAW SPAN



(3) LIFT SPAN

(2) *Suggested modification for draw span*
(3) *Suggested modification for lift span*

Figure 299. Anchor and guy line systems—Continued.

Pull due to current:

$P_1 = A_1v^2$ where P_1 = pull in pounds.
A_1 = vertical cross section below water line at beam of barge in square feet.
v = velocity of current in feet per second.

Pull due to wind:

On barge:

$P_2 = 2A_2p$ where P_2 = pull in pounds.
A_2 = vertical cross section above water line at beam of barge in square feet.
p = pressure per square foot for appropriate wind velocity in table 71.

On superstructure:

$P_3 = \frac{2000}{10}(L_1p_1 + L_2p_2 + L_3p_3)$ where P_3 = pull in pounds.
L_1, L_2, L_3 = length of superstructure in feet of a particular type, table 71.
p_1, p_2, p_3 = pressure in tons per 10-foot length for a particular type superstructure, table 71.

The pull due to current and wind is computed based on maximum expected conditions.

(2) Anchor lines should pull parallel to current.

(3) Winches should be placed on barges to adjust tension in anchor lines.



Figure 300. Anchor barge loaded with scrap metal being towed into position for sinking.

Table 71. Wind Pressures

Wind pressure in tons per 10-foot length of superstructure

Type of bridge	Wind velocity (mph)			
	40	60	80	100
Single-single	0.09	0.19	0.34	0.53
Double-single	0.10	0.24	0.41	0.65
Triple-single	0.11	0.25	0.44	0.67
Double-double	0.18	0.40	0.72	1.12
Triple-double	0.20	0.45	0.80	1.24
Double-triple	0.28	0.64	1.13	1.77
Triple-triple	0.29	0.66	1.18	1.85

Wind pressure on vertical surface

Wind velocity mph	40	60	80	100
Wind pressure (lbs per sq ft)	5.1	11.5	20.5	32.0

251. Guy Lines

a. Landing-bay piers are anchored to bank by using guy lines. These lines should be placed at approximately 45-degree angle to bridge centerline.

b. Longitudinal tie cables from stern to stern and bow to bow of each barge assist in keeping bridge alined and prevent longitudinal movement of parts of the bridge.

c. Special spans require modification of the anchor and guy system as shown in figure 299 ② and ③. In the lift span and draw span, the longitudinal tie cables must be broken to allow passage of river traffic. In lift spans, extra cables can be strung over the top of the towers to tie the bridge together over the gap. In draw spans, extra anchor barges may be sunk at each side of the gap to prevent the bridge shifting when the span is opened.

252. Anchorage of Grounding Barges

a. Barge Slide. A barge which tends to slide down the bank when grounded must be suitably anchored to the shore. Cables fastened to the bank can be passed under the barge to connection on the off-bank gunwale of the barge. Packings must be used to prevent damage to the barge chines by the cables.

b. Landing Bay Slide. When barge slides on grounding, the resulting shift in superstructure may cause the landing bay to slide beyond

the limits allowed for the bearings on the base plates. Tackle can be rigged to prevent further movement until the bearings and base plates can be reinstalled and secured in proper position.

Section VIII. MAINTENANCE

253. Maintenance Detail

A detail of approximately one engineer combat company is required for maintenance of an 800-foot panel bridge on a 24-hour-a-day basis. Normally, two squads per shift are enough to tighten bolts, check anchor cables, repair decking, and maintain adequate bridge signs. On this basis, six squads in 24 hours are utilized, leaving a remainder of three squads to be detailed for the following duties:

a. Maintenance of approach roads.
b. Reserve for any major repairs required.
c. Traffic guide for large vehicles across the bridge.
d. Crews for fireboat and stand-by tugs.

254. Duties

a. A duty officer should be detailed at the bridge 24 hours a day.

b. Bridge duty officer should insure that the following regulations are in force at all times:

(1) Communication must be maintained between the ends of the bridge.

(2) A wrecker must be available on call to remove disabled vehicles from the bridge.

(3) Guides having thorough knowledge of standard hand signals must be available to guide minimum clearance vehicles across the bridge.

(4) Alinement of bridge must be constantly maintained.

(5) Tension in all anchor cables must be kept uniform.

(6) Buffers must be maintained between all anchor and guy cables that rub against metal.

(7) All cable connections must be inspected twice in 24 hours.

(8) All pins, bolts, and clamps must be inspected once in 24 hours.

(9) All barges must be inspected and bailed once in 24 hours.

(10) All base plates must be inspected once in 24 hours.

(11) Source of power must be available on the bridge electric circuit for operation of trouble lights and tools.

(12) Immediate approach roads must be maintained.

(13) All signs in the vicinity of the bridge must be maintained.

(14) Traction strips and decking must be maintained. All nail heads must be kept flush with surface.

(15) Tugs must be stationed upstream and downstream at the bridge.

(16) Fireboat must be available.

Section IX. RAFTS

255. Use

Multiple-lane rafts can be constructed from panel-bridge equipment supported on barges. Such rafts can be used either as trail or free ferries in swift currents and rough water because of ample freeboard and stability.

256. Construction

a. Normally, the raft superstructure is DS or TS construction. For details of assembly and launching, see paragraph 243. For barge preparation, see paragraph 241.

b. A typical barge raft that was used successfully is shown in figure 301. This raft has a three-carriageway superstructure of four DS girders 90 feet long on two 100-ton capacity Thames type barges. This raft accommodates 12 vehicles having a combined weight of 120 tons.

c. Inset position of barges in the raft as shown in figure 301 is necessary except in cases where the raft will be used in smooth water; otherwise, if the barges are placed near the ends of the raft, excessive stresses are induced in the connections between the barges and superstructure in rough water.

d. When towing the raft in heavy seas, the decks may become awash causing complete bays of decking to lift off the barges. To prevent this, stringer clamps are used.

e. Superstructure must be secured to the barges to prevent fore and aft movement. Sway braces can be used for this purpose by fixing one end of the brace to a barge deck bollard or cleat and attaching the other end to a deck transom by means of two tie plates. The brace can then be tightened in the normal manner.

f. Construction and operation of a raft is facilitated by use of quays or docks. It is preferable to operate between quays or docks of proper height for convenience in loading and unloading the raft. Where such site conditions exist, the height of the raft deck can be adjusted, within limits, by packing the superstructure girders up on cribs or by building a deck type rather than a through type. If quays or docks are not available, ramps can be constructed.

257. Operation

a. For continuous use of the raft as a ferry, an upstream cable can be installed. Bridle lines run to winches mounted on the barges, allowing the raft to be swung at suitable angles to the current and operate as a trail ferry.

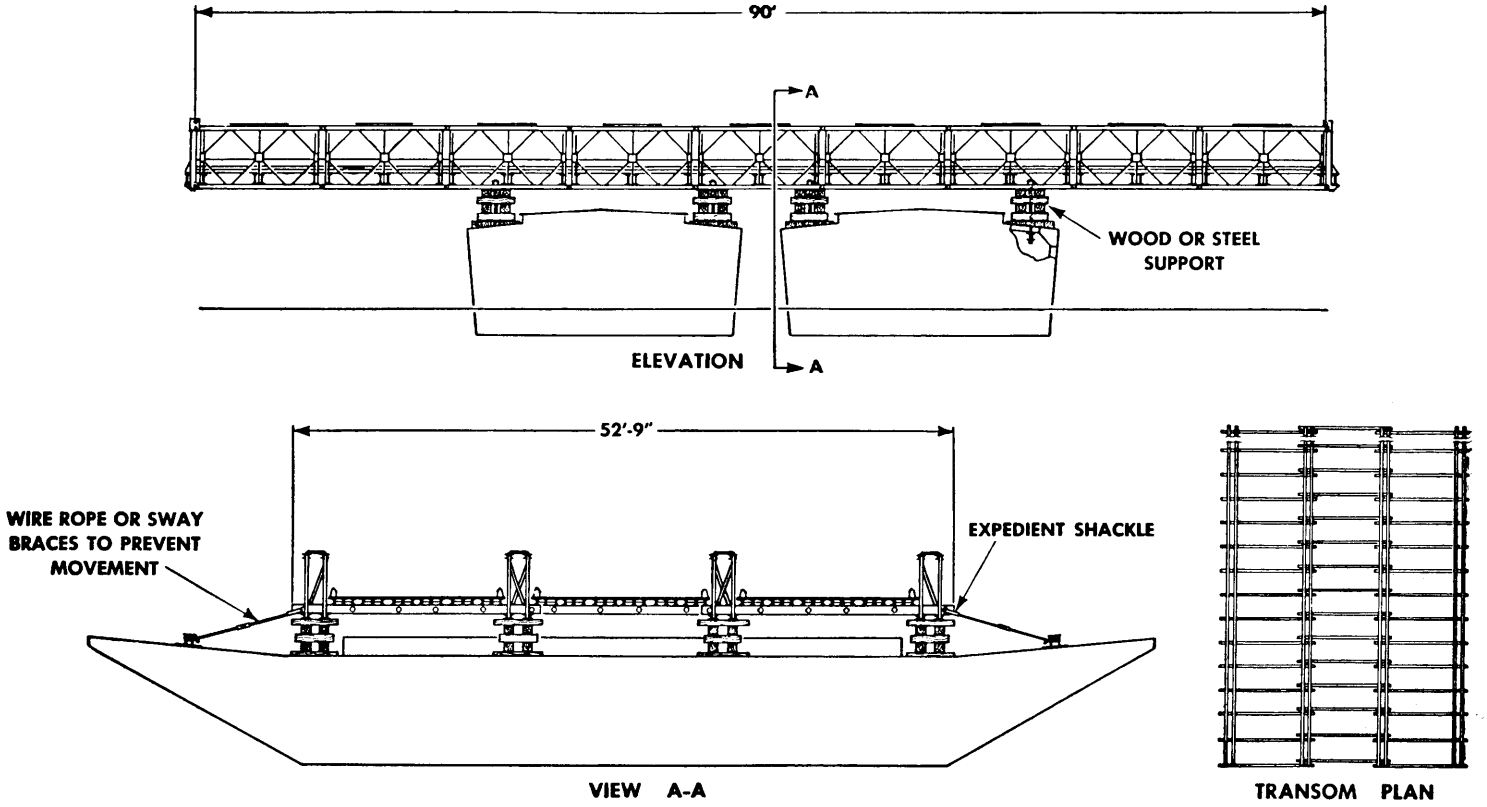


Figure 301. Typical barge raft.

b. In grounding the raft, it is possible that the barges will assume different angles of slope. To relieve the superstructure of stresses, either all top or all bottom pins at the center panel connections of the raft must be removed. This allows the two halves of raft to articulate and conform to the lay of each barge. Close observation is required as the tide falls to determine whether the top or bottom pins are to be removed and also the proper time to remove them.

CHAPTER 27

EXPEDIENT CONSTRUCTION

258. Scope

This chapter describes expedient uses of panel bridge equipment.

259. Strength of Panel Bridge Parts and Erection Equipment

Panel bridge parts are often used in the field to build improvised structures. To aid in their proper use, the capacities of the parts are given here. These data are based on computations by the Engineer Board. In all cases, allowance must be made for impact and load-distribution factors. Table 72 gives the strength of M2 panel-bridge parts, and table 73 gives the strength of panel-bridge erection equipment.

260. Spans Without End Posts

Single-story bridges can be built without end posts or bearings, the bridge resting on timber cribbing under the end vertical member of the end panels. When this is done, the transoms supporting the ends of the last bay of stringers must be supported in either of the following two ways:

a. END TRANSOM NOT SUPPORTED BY TRUSSES. Place end transom outside the verticals of the end panels and on grillage (fig. 302 ①). Place an extra transom in the seating just inside the verticals of the end panel. Wedge blocking between these two transoms and lash them together. The ends of the stringers and ramps rest on and engage with the lugs of the end transom. Bolt bracing frames between the trusses at the end of the bridge. Table 74 lists the maximum spans that can be built with the ends of the bridge supported in this way.

b. END TRANSOM SUPPORTED ON TRUSSES. Add an extra panel to the inner truss on each side of the bridge, and place a transom in this panel on the seating nearest the bridge proper (fig. 302 ②). This transom supports the ends of the stringers and ramps. Place rakers on this transom and bracing frames between the trusses at the end of the bridge proper. Grillage under end vertical is extended 2 feet on each side of the panel joint. Bridges of this construction can carry the same load as corresponding bridges in *a* above. If the additional panel is added to *all* the trusses, the bridges can carry the same loads as corresponding bridges with end posts. In both cases, place cribbing under the center of the end transom when loads are over 30 tons.

Table 72. Strength of M2 Panel-Bridge Parts

①

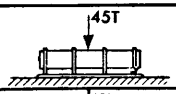
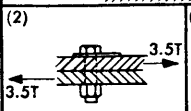
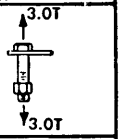
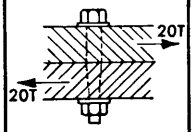
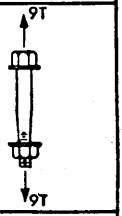
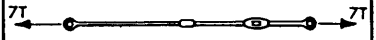
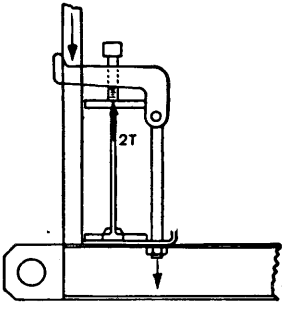
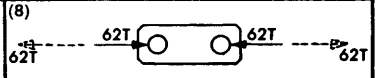
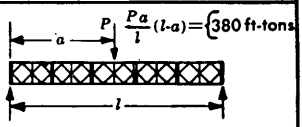
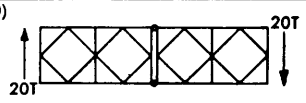
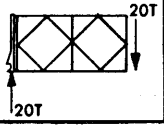
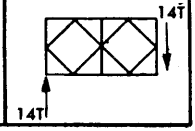
PART	LOAD	STRENGTH (TONS)	ILLUSTRATION
Bearing	(1) Concentric load	45	(1) 
Bolt, bracing	(2) Single shear (3) Tension	3.5 3.0	(2)  (3) 
Bolt, chord	(4) Single shear (5) Tension	20 9.0	(4)  (5) 
Brace, sway	(6) Tension	7.0	(6) 
Clamp, transom	(7) Maximum vertical clamp load when clamping transom in panel	2.0	(7) 
Link, launching-nose MKII	(8) Compression or tension	62	(8) 
Panel as unit	(9) Moment of resistance to bending	380 ft-tons	(9) 
	(10) Shear across junction with both pins fitted	20	(10) 
	(11) End shear reaction with end post in single story (12) End shear without end post in single story	20 14	(11)  (12) 

Table 72. Strength of M2 Panel-Bridge Parts—Continued.

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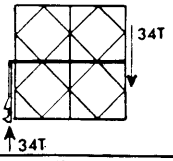
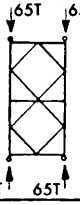
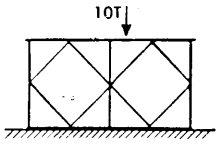
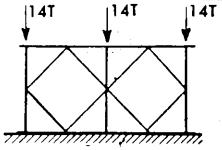
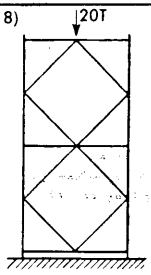
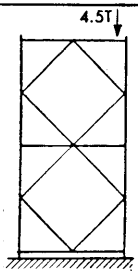
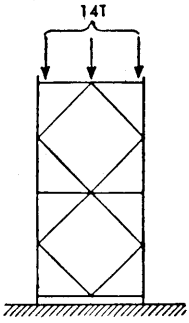
PART	LOAD	STRENGTH (TONS)	ILLUSTRATION
Panel as unit (continued)	(13) End shear reaction with end post in double or triple story	34	(13) 
Panel chord	(14) Tension	80	(14) 
	(15) Compression	65	(15) 
	(16) Local bending, maximum load between panel web members	10	(16) 
Panel verticals	(17) Loaded as a strut	14	(17) 
	Loaded parallel to long axis of panel: (18) Concentrated load at mid-point	20	(18) 
	(19) Concentrated load	4.5	(19) 
	(20) Equal concentrated loads at midpoint and adjacent to both panel chords	14	(20) 

Table 72. Strength of M2 Panel-Bridge Parts—Continued.

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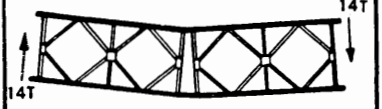
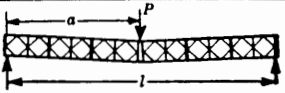
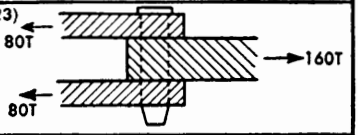
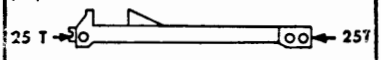
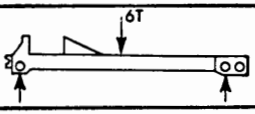
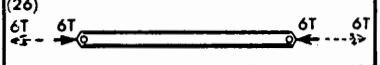
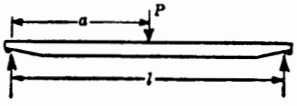
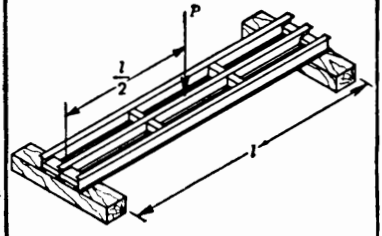
PART	LOAD	STRENGTH (TONS)	ILLUSTRATION
Panel junction with launching link MK II	(21) Maximum shear	14	(21) 
	(22) Moment of resistance	380 ft-tons	(22)  $\frac{Pa}{l}(l-a) = 380$ ft-tons
Pin, panel	(23) Double shear	160	(23) 
Post, end	(24) Compression	25	(24) 
	(25) Concentrated load on center when used as beam supported at pinholes	6.0	(25) 
Raker	(26) Tension or compression	6.0	(26) 
Ramp	(27) Moment of resistance per beam	8.0 ft-tons	(27) $\frac{Pa}{l}(l-a) = \begin{cases} 8 \text{ ft-tons (ramp)} \\ 1.9 \text{ ft-tons (stringer)} \end{cases}$
	(28) Moment of resistance as whole, when point loaded at center	16 ft-tons	
Stringer	(27) Moment of resistance per beam	1.9 ft-tons	(28)  $\frac{Pl}{4} = \begin{cases} 16 \text{ ft-tons (ramp)} \\ 4.9 \text{ ft-tons (stringer)} \end{cases}$
	(28) Moment of resistance as whole, when point loaded at center	4.9 ft-tons	

Table 72. Strength of M2 Panel-Bridge Parts—Continued.

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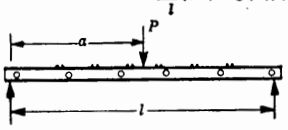
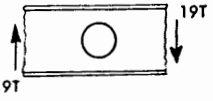
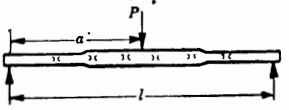
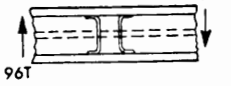
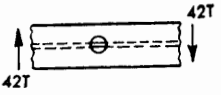
PART	LOAD	STRENGTH (TONS)	ILLUSTRATION
Transom, M2 Normal position	(29) Moment of resistance to bending	64 ft-tons 56 ft-tons (reduced section)	(29) a = 0 to .34l and .66l to 1.0l $\frac{Pa}{l}(l-a)$ = 56 ft-tons a = .34l to .66l $\frac{Pa}{l}(l-a)$ = 64 ft-tons 
	(30) Maximum vertical shear	19	(30) 
Transom, M2 Lying on side	(31) Moment of resistance to bending	10.2 ft-tons 7.5 ft-tons (reduced section)	(31) a = 0 to .34l and .66l to 1.0l $\frac{Pa}{l}(l-a)$ = 7.5 ft-tons a = .34l to .66l $\frac{Pa}{l}(l-a)$ = 10.2 ft-tons 
	Maximum vertical shear: (32) Wide section	96	(32) 
	(33) Reduced section	42	(33) 

Table 73. Strength of Panel-Bridge Erection Equipment

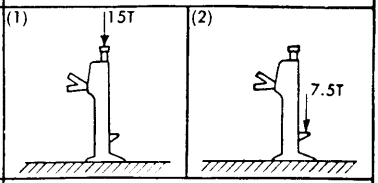
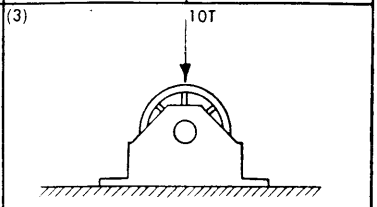
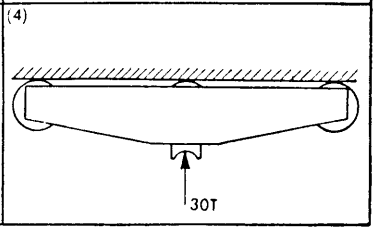
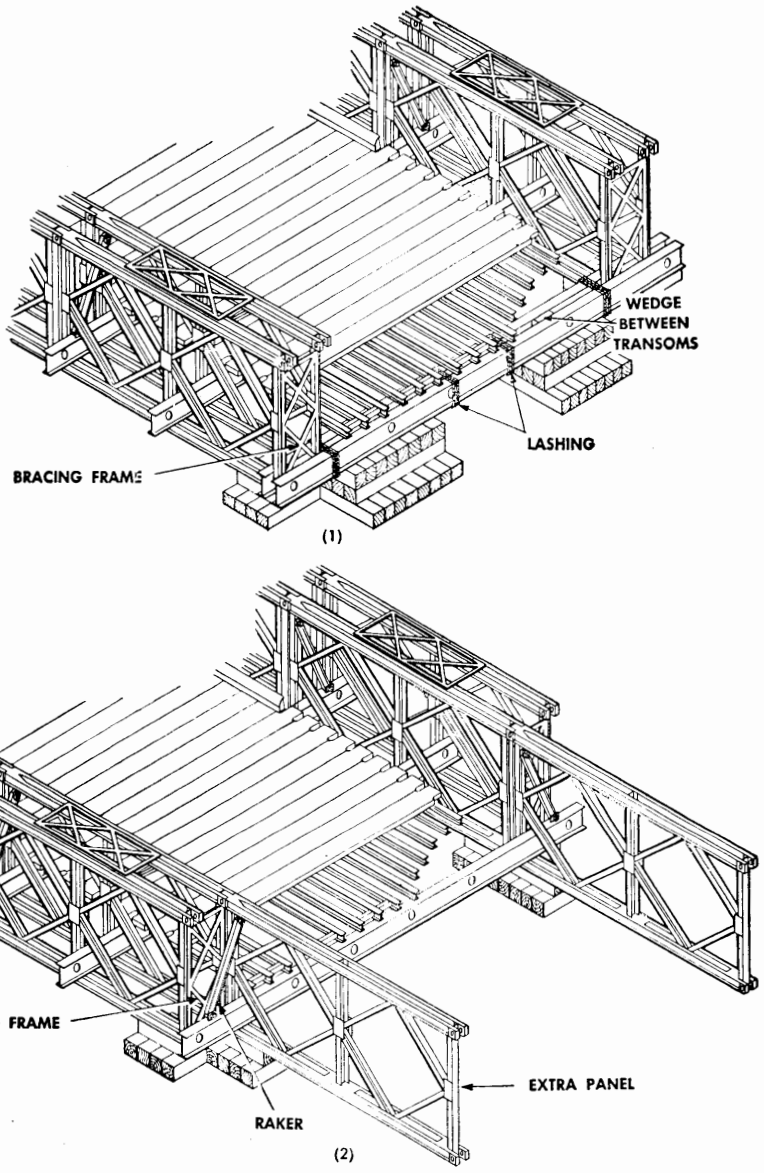
PART	LOAD	STRENGTH (TONS)	ILLUSTRATION
Jack, ratchet	(1) Load on head (2) Load on toe	15 7.5	
Roller, plain	(3) Maximum load	10	
Roller, rocking	(4) Maximum load	30	

Table 74. Limiting Spans for M2 Bridges Without End Posts or Additional Panels[1]

US bridge class (tons)	Type of construction		
	SS	DS	TS
	Maximum allowable span (feet)		
20	40	110[2]	130[2]
30	20	100	120[2]
35	20	80	110[2]
45	..	50	100
65	..	30	50

[1] Maximum allowable shear for bridges without end posts is 14 tons per truss. An allowance of 30 percent of live load is made for impact and eccentricity of load. Limits are based on the effect of tracked vehicles.

[2] Moment governs. Limits same as for bridge with end posts.



①*End transom is not supported by trusses but rests on grillage and is lashed to extra transom seated in end transom seating just inside end panel verticals.*

②*End transom supported in extra end panel.*

Figure 302. Supports for bridge without end posts.

261. Expedient Decking for Panel Bridge

If stringers and chess are not available, an expedient deck can be laid on the transoms of a panel bridge. Timber or steel stringers with a wood floor can be used or steel treadways can be laid on the transom.

262. Causeways

Panel bridge decking can be used to build an expedient causeway over the soft mud of a tidal river bed. The causeway described here (fig. 303) has a capacity of 45 tons and can be used at all stages of tide to load heavy vehicles such as medium tanks on rafts. Its roadway can have a slope up to 1 in 5 and is not affected by heavy tracked vehicles that would normally cause a roadway of landing mats on corduroy material to break up. Use of panel bridge equipment for causeways is, however, expensive in equipment, and should be carefully controlled to prevent a shortage of panel bridge parts.

a. DETAILS. The causeway consists of a normal panel bridge deck of chess, riband, and stringers supported on transoms set in ramp pedestals. To prevent scour and distribute the load, the pedestals rest on a foundation of landing mats and sapling mats (chespaling or similar material). Two pedestals are placed under each transom and the transoms are spaced 5 feet center to center. Precut 4- by 3-inch timber spacers, or rakers with timber wedges, are used between the pedestals to take longitudinal thrust. Sway bracing is threaded through the outside holes in the transom webs and held in place by bolts. The button stringers are wired to the transoms to prevent the decking being lifted by the tide. A nonskid surface is provided by nailing down landing mat, preferably Irving grid, to the chess or wear treads. Steel ribands are used for curbing. Holdfasts at each side of the causeway are used to anchor bays having a steep slope.

b. ERECTION. (1) About 100 man-hours are required to erect 100 feet of this causeway. If the precut timber spacers are used instead of rakers with wedges, erection time can be reduced 25 percent.

(2) Place spacers at the same time as the pedestals, before transoms are laid. Do not tighten sway braces until stringers have been placed.

(3) The maintenance party keeps wedges, sway braces, and anchor lines tight.

c. OPERATION. (1) At low tide, and at high tide during construction of the causeway, vehicles generally can be loaded and unloaded at the end of the causeway. The overhanging deck or adjustable ramp of the raft rests on the end bay of the causeway so vehicles pass directly from the raft deck to the causeway. Where the causeway is begun at high tide, bays can be added at the rate of one bay in about 20 minutes as the tide lowers.

(2) At high tide, the lower end of the completed causeway is submerged and rafts are loaded and unloaded at the higher bays. An

adjustable landing ramp hinged to the raft is used to bridge the gap between the causeway and shore end of the raft. The shoreward ponton can be grounded on the submerged causeway, but care must be taken to position the raft so the water is deep enough to permit maximum displacement when the shoreward ponton grounds.

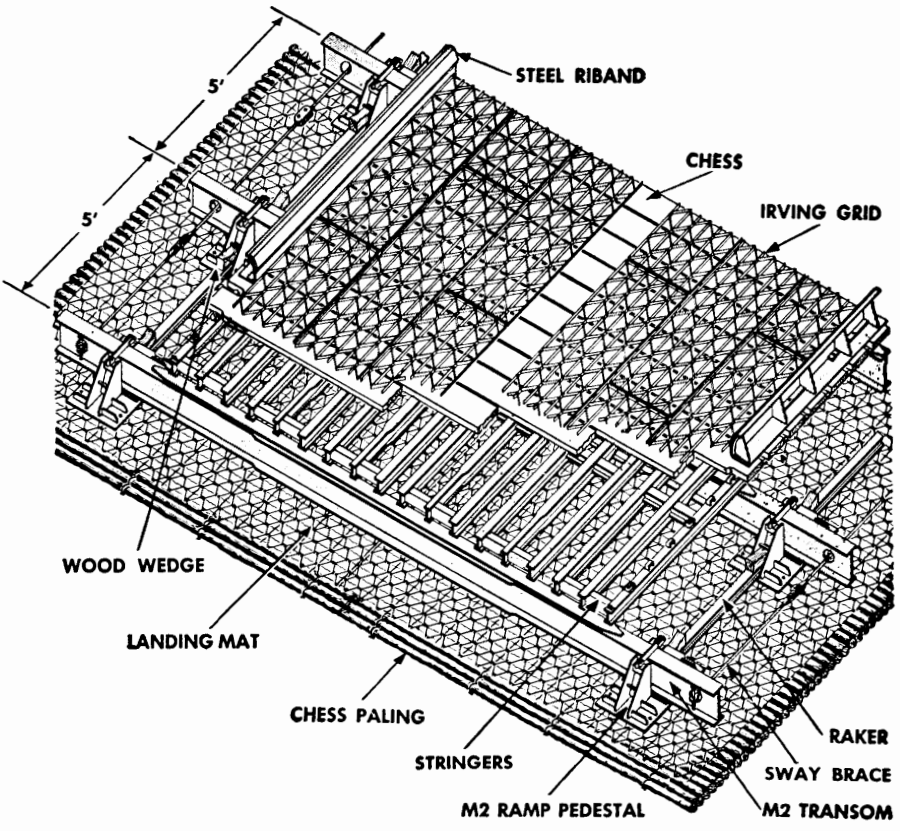


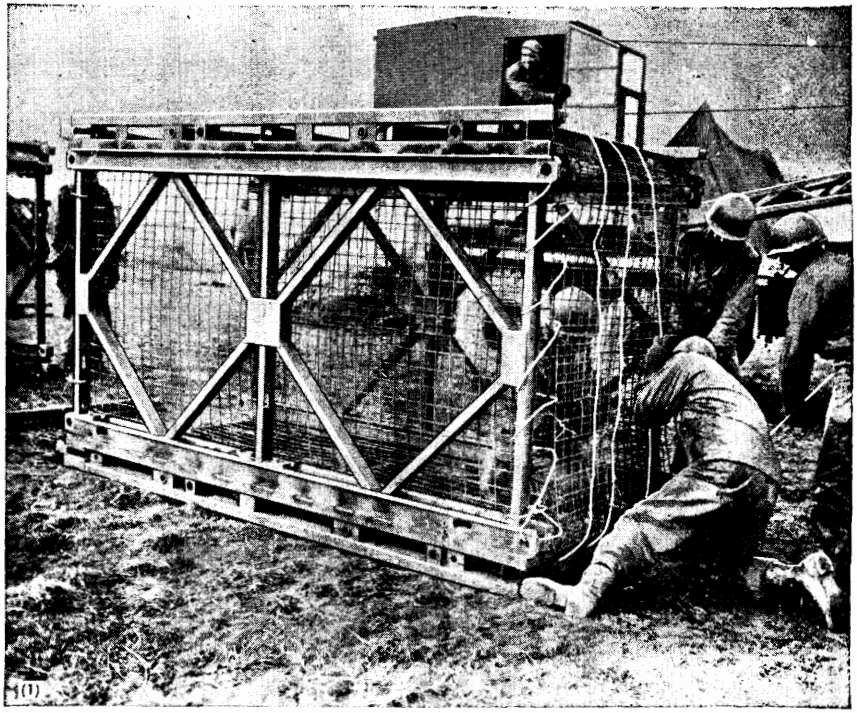
Figure 303. Panel bridge causeway.

263. Panel Box Anchors

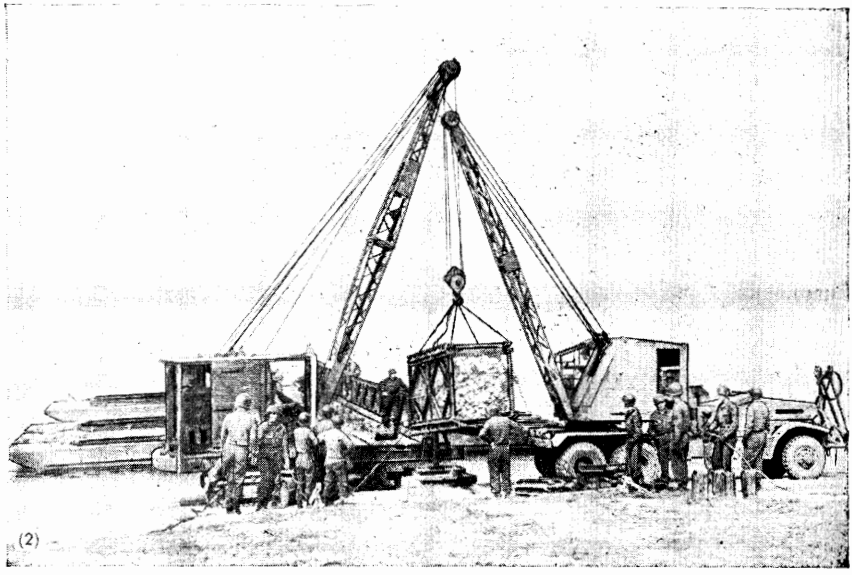
An expedient heavy rubble box anchor can be made from four panels welded into a box lined with heavy wire net and filled with rock as illustrated in figure 304. Completely filled with rock, the anchor weighs about 10 tons. Heavy anchors of this type were used to anchor heavy floating bridges in swift currents and in stream beds in which the standard anchor would not hold.

264. Other Expedient Uses

Panel bridge parts can be used to build gantries (fig. 305), anchor-cable towers (fig. 271), high-line towers (fig. 306), truck-loading traps (fig. 307), structures when other building materials are not available. Angles and I-beams can be salvaged from damaged panel-bridge parts to be used for expedient construction.



①*Installing heavy wire-net lining inside box made by welding four panels together*



②*Loading completed box anchor onto raft before ferrying anchor into position*

Figure 304. Panel box anchor.

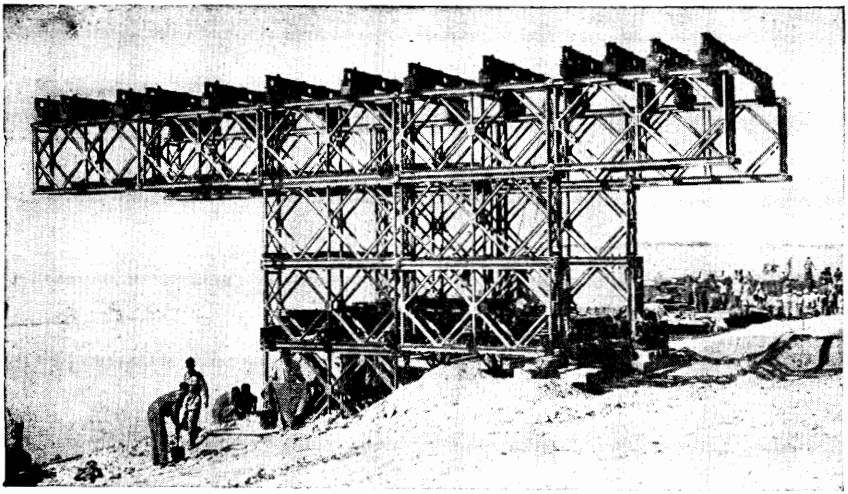


Figure 305. Constructing a ship-building gantry from panel bridge parts. To complete gantry, a monorail and traveling crane will be hung from overhead transoms.

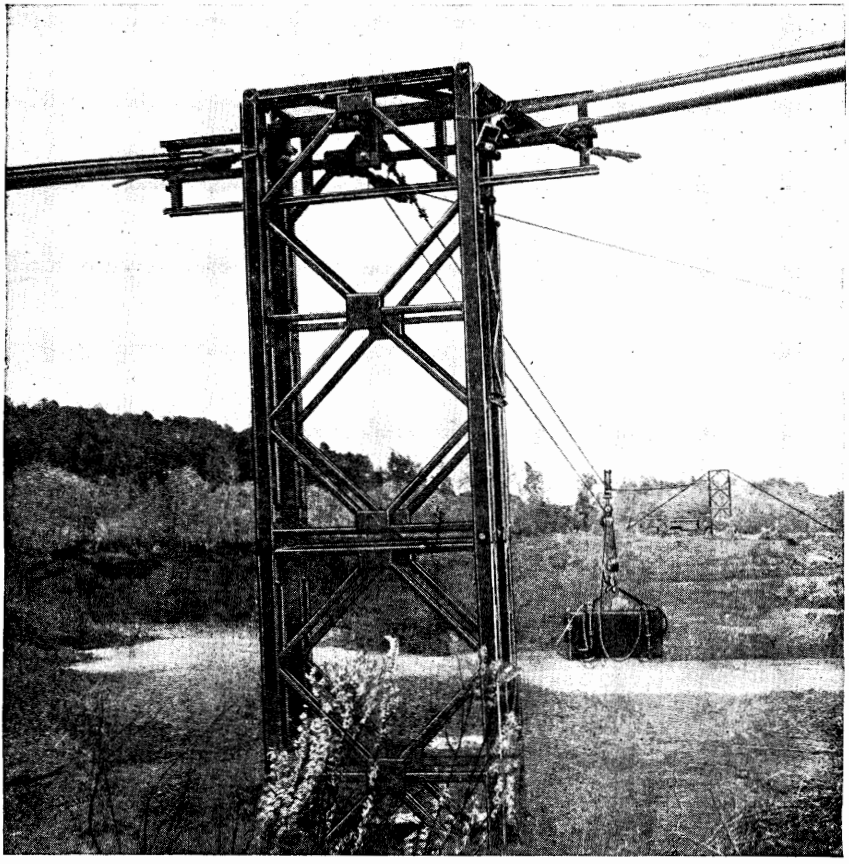


Figure 306. Expedient high-line tower. Tower is made from two panels set on end and partially buried.

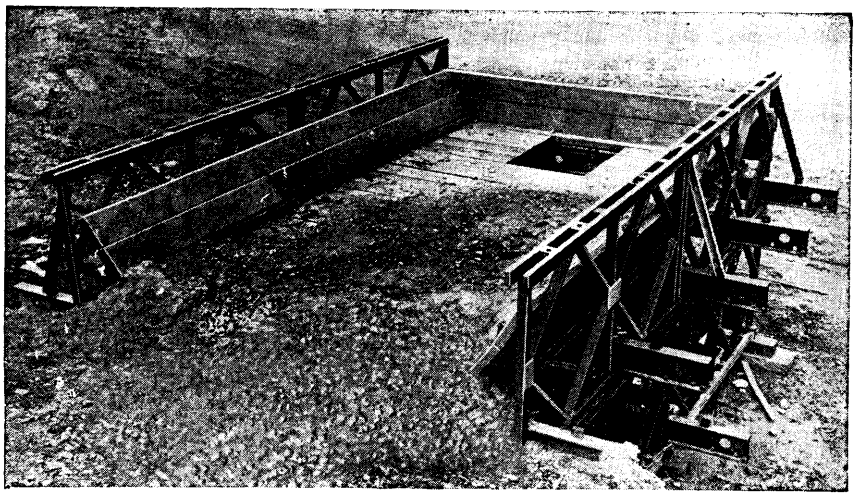


Figure 307. Truck-loading trap made from panel-bridge parts.

PART FOUR
SPECIAL LAUNCHING METHODS

CHAPTER 28
LAUNCHING IN RESTRICTED SITES

Section I. GENERAL

265. Purpose

This chapter gives detailed information for launching fixed panel bridges in restricted sites. General design principles and limitations are included to aid qualified personnel in solving special launching problems.

266. Restricted Sites

A restricted site prevents normal roller lay-out and launching by the standard skeleton launching nose method described in chapters 9 and 11. Space on either bank may be restricted in length or width by obstructions such as buildings, existing bridge girders, trees and earthwork or by sloping banks and canal dikes. Limited *back space* or length of construction area on the near bank is the most common restriction. Back space is measured from near-bank rocking rollers to the limiting obstruction ((1) fig. 309). Far-bank conditions are a less common restriction because standard launching tables allow progressive dismantling of all launching noses and this requires a minimum clear distance of only 12 feet beyond the far-bank rollers. Several methods included in this chapter, however, reduce far-bank requirements even more by landing directly on bearings (pars. 269, 271, 272, and 274) and by inverting nose construction (par. 270) to clear low obstructions such as existing bridge girders.

Section II. COUNTERWEIGHT LAUNCHING

267. General

a. SCOPE. This section describes launching of fixed panel bridges using fixed and movable counterweights with—

(1) *Standard launching nose construction* for sites with limited back space on near bank. Several bridge bays are omitted during launching. Counterbalance of the span is maintained by placing a counterweight in the last bridge bay equivalent to the missing bays.

(2) *Launching tail construction* for sites with far bank limitations preventing use of launching nose or far-bank rollers. A counterweighted tail is used instead of the standard skeleton nose to keep the balance point behind the near-bank rocking rollers during launching. Bridge is launched with end posts mounted on leading end and landed directly on far-bank bearings.

b. COUNTERWEIGHT. (1) *Fixed.* Fixed counterweight is added to the end bay of bridge or tail just before final launch to the far bank. Any available material of known weight such as spare bridge parts, sand bags, or vehicles can be used.

(2) *Movable.* Movable counterweight is added earlier in bridge construction and rolled back onto successive end bays to counterbalance progressive launching stages. The two types of rolling counterweight are:

(*a*) *Vehicles.* Trucks, trailers, tanks, tractors, and bulldozers mounted on the bridge deck are pushed, or moved back under their own power as construction progresses. Vehicles can be loaded to weights shown in launching tables or shifted slightly in position on deck of the end bay to provide correct counterbalance. Backspace is often increased by requirements for ramps and space to maneuver and mount vehicle on deck.

(*b*) *Rolling platforms.* Figure 308 shows two movable platforms rolling on inverted plain rollers. Additional counterweight is added in the form of spare bridge parts, sand bags, or any available material of

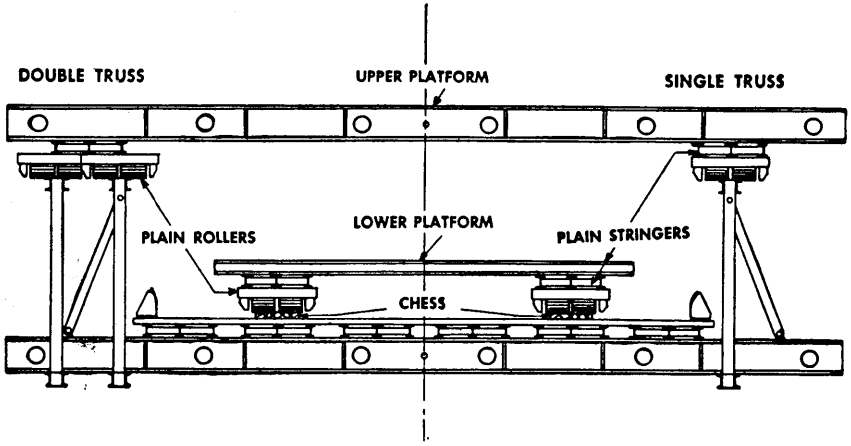


Figure 308. Rolling platform counterweights.

known weight. Platforms can be used singly or together with either a skeleton launching nose or launching tail. Special details in construction and launching are as follows:

1. Four plain rollers are required for all lower platforms and for all upper platforms on SS bridges. Upper platforms on double- and triple-truss bridges require 8 rollers. In triple-truss construction upper platform rollers must not bear on

the outer trusses. Rollers need not be fastened to the stringer frame work.

2. Platforms are moved by block and tackle on both trusses.

3. Horizontal bracing frames on top bridge chord are added after bays have passed under upper platform rollers.

c. BACKSPACE. Table 75 shows backspace required to launch panel bridges by the standard launching nose method and by both counterweight methods using either fixed or rolling counterweights. Center of gravity or balance point of the bridge is always kept at least 2 feet behind the near-bank rocking rollers. Figures also include 12 feet to add last bay of bridge or tail.

d. LIMITATIONS. All counterweight methods increase launching weights. Maximum spans launched by these methods are therefore shorter than those launched by the standard launching nose method because of the resulting increase in combined stress in the lower chord over the launching rollers.

268. Launching Nose and Counterweight

a. CONSTRUCTION AND LAUNCHING. Length of launching nose, composition of nose and bridge bays and organization of working parties are the same as in standard launching method (ch. 11). However, use of counterweight instead of end bays as counterbalance for cantilever launch to far bank requires the following changes:

(1) *Roller lay-out.* On DS construction use plain rollers in pairs (one under each truss) instead of singly as in standard method.

(2) *Adding counterweight.* All launching noses can be moved forward from 12 to 17 feet after construction of first bridge bay to allow mounting of rolling counterweight on deck. If more space is needed add temporary fixed counterweight to bridge or adjacent nose bay and launch nose further over gap.

(3) *End-bay construction.* Construct all bridge bays complete for final launch to far-bank rollers except for TS and DD bridges which are DS construction in end bay.

(4) *Completion of bridge.* To speed construction, after landing on far bank, add remaining bridge bays, complete the launch and remove nose. Install far-bank end posts, jack down and install ramps. Move rolling counterweight to far-bank end of bridge, install near-bank end posts, and jack down. Position near-bank ramps and remove counterweight.

b. LAUNCHING TABLE. Table 76 gives construction for all bridges that can be launched with an appreciable reduction in back space over the standard method using either fixed or rolling counterweight of the amount shown. Data is based on following assumptions:

(1) All counterweight is centered in end bay of bridge.

Table 75. Backspace in Feet Required to Launch Fixed Panel Bridges[1]

Bridge		Launching method				
		Standard nose			Tail	
		Counterweight				
Type	Span (feet)	None[2]	Fixed[3]	Rolling[3]	Fixed[4]	Rolling[4]
SS	30	35	28	26	30	24
	40	43	31	31	35	24
	50	47	37	32	40	24
	60	55	41	36	50	33
	70	63	48	42	55	33
	80	67	53	42	60	34
	90	75	56	46	70	43
DS	50	45	36	32	41	26
	60	52	39	36	51	33
	70	57	43	36	56	33
	80	64	51	43	61	34
	90	71	54	46	66	34
	100	76	58	46	75	43
	110	83	65	51	85	53
	120	90	68	56		
	130	95	77	63		
TS	80	63	50	42	68	43
	90	70	53	46	73	43
	100	74	57	46	83	53
	110	81	64	52	93	63
	120	86	69	53		
	130	93	76	62		
	140	100	78	62		
DD	100	74	61	52	80	52
	110	81	65	54	85	52
	120	86	67	52	86	53
	130	93	74	62	87	53
	140	100	77	62		
	150	106	87	72		

[1] All back spaces include 2 feet between center of gravity of bridge and near-bank rocking rollers and 12 feet to build last bay of bridge or tail.

[2] Standard staggered construction and launching (chs. 11, 12 and 13).

[3] See par 268 and table 76.

[4] See par 269 and table 77.

(2) Minimum backspace for any bridge is that required to build launching nose and first bay of bridge without counterweight.

(3) Length of bridge for launching with rolling counterweight of amount shown in table 76 requires approximately the same back space as required to build nose and first bay.

Table 76. Construction for Launching with Standard Launching Nose and Counterweight

Type of construction	Span (feet)[1]	Construction for launching			Back space (feet)		Counterweight (tons)[5]	Launching weight (tons)	Sag (in.)[6]
		Bays of bridge[2]	Bays of nose		Fixed counterweight[3]	Rolling counterweight[4]			
			SS	DS					
SS	30	2	2		28	26	3.1	11.0	2
	40	2	3		31	31	7.7	16.5	3
	50	4	3		37	32	4.2	18.5	4
	60	4	4		41	36	7.3	23.0	7
	70	5	5		48	42	4.2	23.5	10
	80	6	5		53	42	8.3	30.5	13
	90	6	6		56	46	11.4	34.5	20
DS	50	4	3		36	32	3.8	21.0	3
	60	4	4		39	36	7.0	25.0	5
	70	5	4		43	36	13.7	35.0	7
	80	6	5		51	43	8.0	34.0	12
	90	6	6		54	46	11.0	38.0	17
	100	7	6		58	46	15.0	45.5	20
	110	8	7		65	51	15.7	50.5	28
	120	8	8		68	56	15.0	50.5	38
	130	10	8		77	63	13.2	55.5	45
TS	80	6	5		50	42	8.3	37.0	11
	90	6	6		53	46	11.3	41.0	17
	100	7	6		57	46	18.3	52.0	20
	110	8	7		64	52	12.3	51.1	26
	120	9	7		69	53	18.7	61.5	30
	130	10	8		76	62	13.5	61.5	42
	140	10	9		78	62	16.3	65.0	57
DD	100	8	6		61	52	9.7	52.1	15
	110	8	7		65	54	12.5	54.0	19
	120	9	7		67	52	19.6	68.0	22
	130	10	8		74	62	13.7	67.4	29
	140	10	7	2	77	62	18.1	74.1	36
	150	12	6	3	87	72	17.5	83.4	38

[1] Launching spans 5 feet less than bridge spans.

[2] All bridge bays decked and complete at critical launching stage except that end bays of TS and DD bridges are DS construction. Bridges launched without footwalks.

[3] Fixed counterweight added to end bay for final launching only.

[4] Rolling counterweight added on first bridge bays and rolled back onto successive end bays.

[5] Counterweight 5 feet from end of bridge.

[6] Sags are approximate.

269. Launching Tail and Counterweight

a. DESCRIPTION. Launching tail method differs from the standard nose and counterweight method (par. 268) in the following details:

(1) *Composition.* Tail is of exactly the same construction as bridge bays (fig. 309). All bridges are launched without deck and stringers except end bay of tail when using fixed counterweight.

(2) *Roller lay-out.* End posts mounted on leading end of the bridge and landing directly on bearings eliminate rollers and jacking down on far bank.

(3) *Length of bridge.* Length of bridge required is 2 feet 6 inches longer than launching span or gap instead of 5 feet for the launching nose method (fig. 309).

(4) *Allowance for sag.* Since there is no nose into which launching links can be inserted, allowance for sag must be made by difference

Table 77. Construction for Launching with Tail and Counterweight

Bridge[1]		Back space (feet)		Tail[3]		Launching weight (tons)	Sag (in)[5]
Type of construction	Span (feet)[2]	Fixed CW	Rolling CW	Length (bays)	Counterweight (tons)[4]		
SS	30	30	24	1	5.0	12.5	1
	40	35	24	1	11.0	19.5	2
	50	40	24	1	18.5	28.5	3
	60	50	33	2	10.0	22.5	5
	70	55	33	2	15.0	29.0	8
	80	60	34	2	20.5	35.5	12
	90	70	43	3	15.5	33.0	18
DS	50	41	26	1	28.0	42.0	3
	60	51	33	2	15.0	32.5	5
	70	56	33	2	22.5	42.0	7
	80	61	34	2	30.5	52.0	10
	90	66	34	2	40.0	63.5	15
	100	75	43	3	29.5	57.0	
	110	85	53	4	24.5	56.0	27
TS	80	68	43	3	22.5	52.5	11
	90	73	43	3	31.0	64.0	16
	100	83	53	4	25.5	63.5	20
	110	93	63	5	23.0	66.0	26
DD	100	80	52	4	33.0	80.0	12
	110	85	52	4	41.5	91.5	16
	120[6]	86	53	4	43.5	94.5	18
	130[7]	87	53	4	44.5	95.0	20

[1] Launched without footwalks, deck and stringers. Launched with far-bank end posts.

[2] Launching spans 2 feet 6 inches less than bridge spans.

[3] Tail construction same as bridge.

[4] Counterweight 5 feet from end of bridge. Add 1.5 tons in place of deck and stringers in end bay when using rolling CW.

[5] Sags are approximate. Add 6 inches for end post projection.

[6] Two bays of second story omitted at leading end of bridge.

[7] Five bays of second story omitted at leading end of bridge.

in elevation between near-bank rocking rollers and far-bank bearings unless site conditions allow cantilever end of a manually launched bridge to be raised by bearing down on the tail as end posts near the bearings.

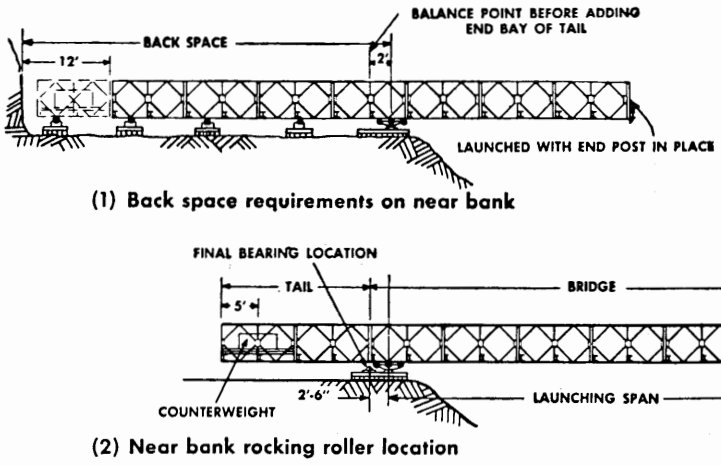


Figure 309. Site lay-out for launching with tail and counterweight.

b. LAUNCHING TABLE. Table 77 gives necessary data for launching with tail and counterweight. Tails shown are of minimum allowable length to maintain chord stresses over rocking rollers within allowable limits. Where site permits use of longer tails, corresponding lighter counterweights can be calculated by taking moments about near-bank rocking rollers. When using rolling counterweight (upper platform, fig. 308), values shown in table must be increased 1.5 tons in place of end bay deck and stringers.

Section III. SPECIAL METHODS

270. Inverted Launching Nose

Far-bank sites with low obstructions and limited clearance widths, such as low sidewalls or existing girders on narrow piers, which interfere with launching nose transoms can often be cleared with inverted launching noses. Construction is the same as in standard launching tables except that nose panels are inverted and transoms, rakers, and sway braces are in the upper instead of the lower chord. Vertical clearance beneath transoms is increased 3 feet 6 inches. Launching links are placed in the lower chord as in the standard nose.

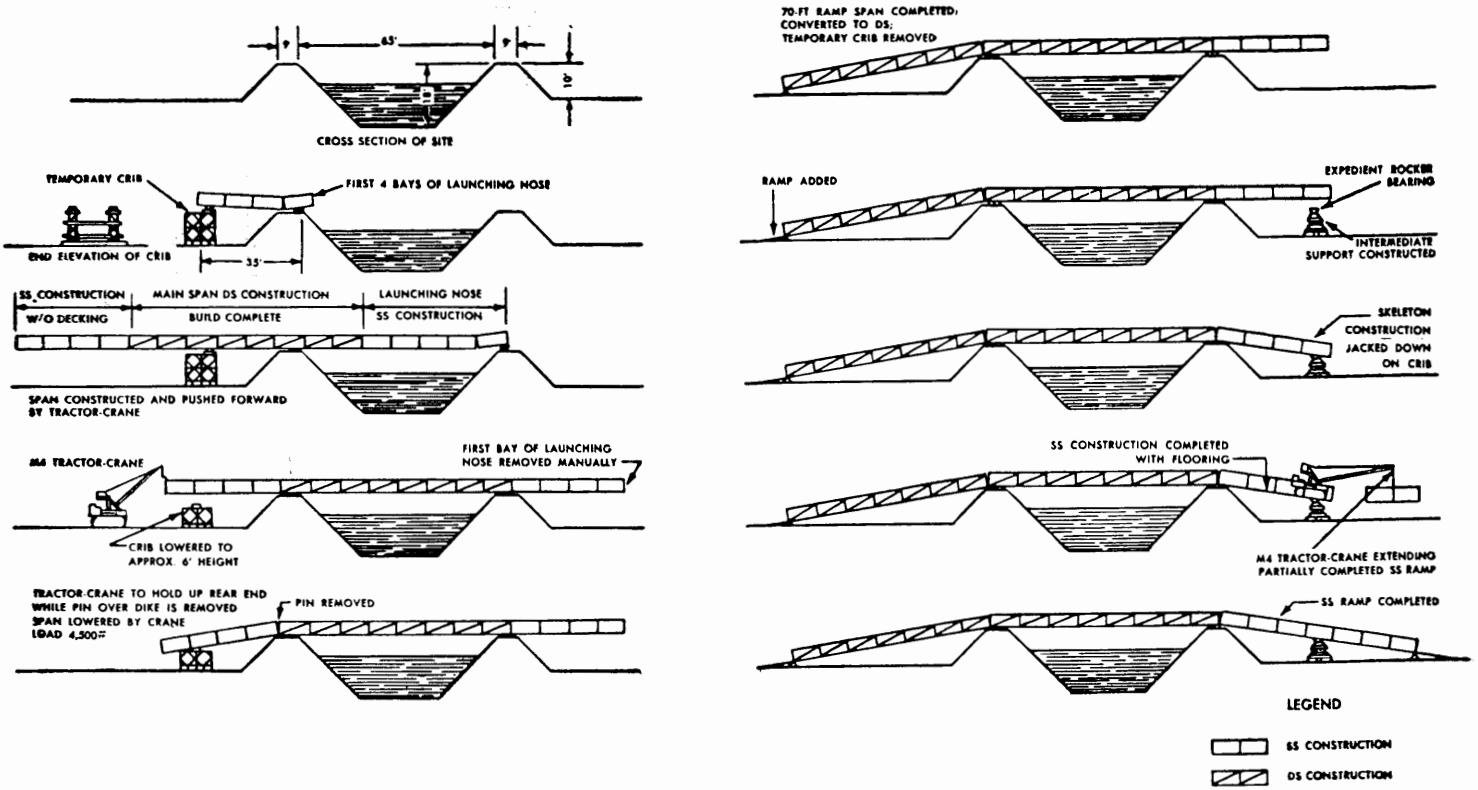


Figure 310. Method of erecting panel bridge, Bailey type, for bridging 65-foot diked canal.

271. Launching Platforms

a. CRIB PIERS. In launching from sloping banks or over canal dikes (fig. 310) rollers can be supported on panel crib piers (ch. 25) to provide a level launching site.

b. FALSEWORK. Panel bridges can be built in place or launched without nose or tail over continuous timber or panel falsework or cribs 25 feet on centers across the gap. With rollers spaced 25 feet apart sag requires jacking of leading end as it reaches roller position. For a DS bridge the sag of the leading end will be 2 to 3 inches with a 25-foot overhang.

272. End-on Erection

a. DESCRIPTION. End-on erection of a panel bridge is the successive addition of bays on the cantilever end over the gap. No rollers are used. The bridge is supported during construction on packing of timber and transoms under the bottom chord. Counterbalance is provided by either the simultaneous addition of tail of same length and construction as the bridge or by a shorter tail and heavy counterweight. Panels are positioned with improvised davits and rope tackle.

b. APPLICATION. This method can be used on all types of restricted sites, being particularly adapted to building from the top of canal

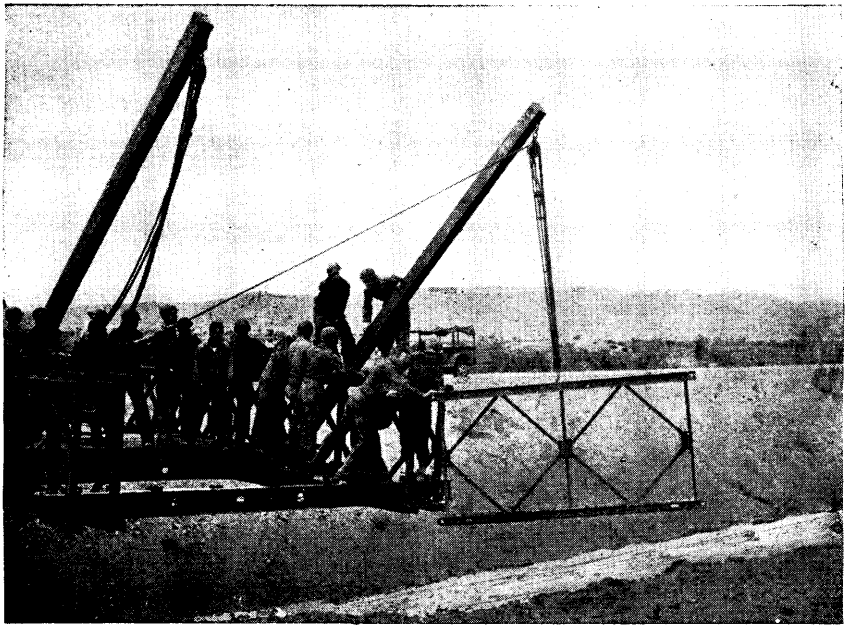
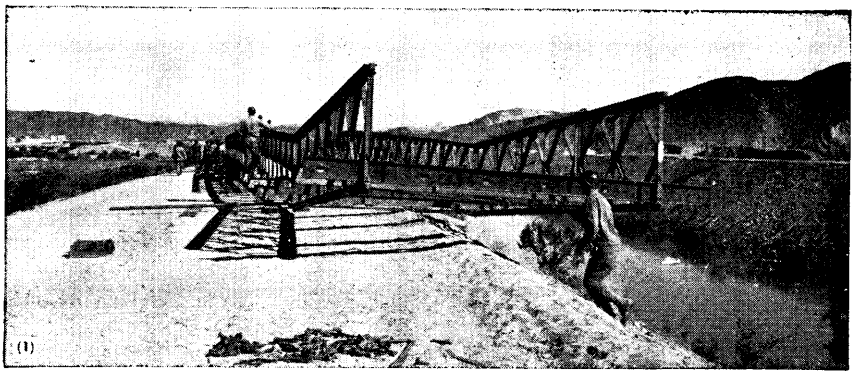
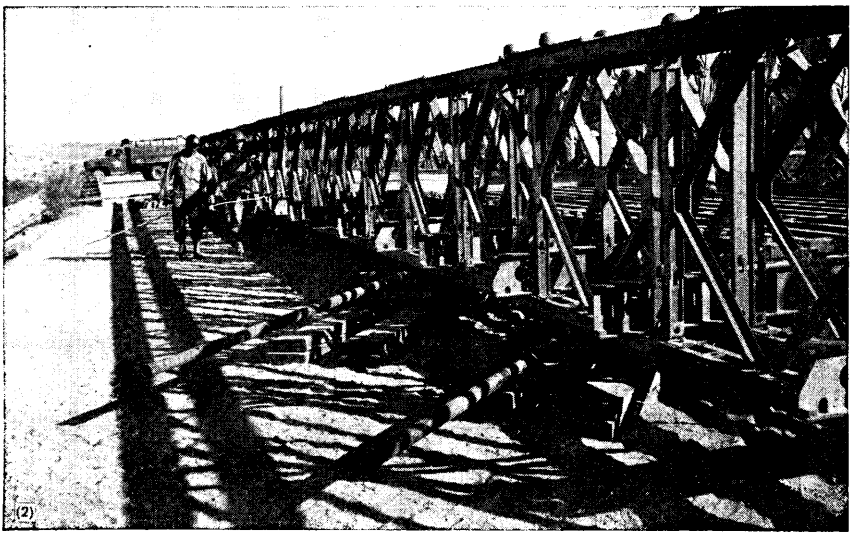


Figure 311. Improvised timber davit.



①*Nose beginning to swing*



②*Improvised pipe rollers*

Figure 312. Launching by swinging method.

dikes. Using the short tail and counterweight it requires the least backspace of any launching method.

c. CONSTRUCTION DETAILS. Forward packing at the edge of the gap must distribute the weight of the bridge over at least 3 feet of the bottom chord to prevent buckling. Rear packing supporting the tail must be low enough to give sufficient initial slope to counteract sag and bring end posts over far-bank bearings.

d. DAVITS. A timber (8″ x 8″ x 20′ 0″) and a 4-way block and tackle with ¾-inch rope can be used as an improvised davit. Braced at a 45° angle (in DS and TS construction against the horizontal bracing frame on the top chord and a transom at the lower end) so the upper

end of the timber extends about 5 feet above and beyond the end of the trusses, each new panel can be accurately placed with the block and tackle suspended from the upper end of the timber (fig. 311).

e. COUNTERWEIGHT. Tail and counterweight are kept to a minimum by installing only such decking on the cantilever over the gap as required to operate the davits.

273. Swinging

Panel bridges can be swung across diked canals by building complete with launching nose or tail on top and parallel to the near-shore dike and pivoting the bridge about its balance point on improvised pipe rollers (fig. 312).

274. Launching by Single Girders

Building sites of adequate length but less than the minimum 20 feet 9 inches width required for a complete bridge can be used for launching by single girders (ch. 29).

275. Launching by Flotation

Bridges can be floated into place on restricted sites over navigable channels if adequate building sites and pontons are available (ch. 31).

CHAPTER 29

LAUNCHING BY SINGLE GIRDERS

276. General

This chapter describes the launching of panel bridges one girder at a time.

a. USE. This method is used advantageously when—

(1) Launching from an existing bridge where piers are wide enough to take ends of a new span, but existing bridge is not wide enough to launch the new span complete. Examples are—

(*a*) Existing through-type panel bridge (fig. 313①).

(*b*) Existing through-type civilian bridge where width between side walls or trusses is less than 20 feet 8½ inches (fig. 314①).

(*c*) Existing deck type bridge where width of deck is less than 20 feet 8½ inches (fig. 314②).

(*d*) Launching span of panel bridge to a point much lower or of varying height, as to intermediate landing-bay of a floating bridge in tidal water (fig. 313②).

(2) Launching deck-type panel bridge (fig. 313③).

b. TYPES OF GIRDERS. (1) *Description.* Single girder may be made up of a single truss or of two or more trusses connected together by bracing frames and tie plates. Five trusses are the maximum number that can be handled practicably. Figure 315 shows girders with various combinations of two to five trusses.

(2) *Use* (*a*) Single-, double-, and triple-truss girders are used for through-type panel bridges.

(*b*) Any of the girders may be used for deck type panel bridge. To save launching time, the wider girders are used in preference to many narrow girders. Four- and five-truss girders usually are used for multilane deck type bridges.

c. CONSTRUCTION SEQUENCE. (1) A girder is assembled on the deck of existing bridge and then launched over the gap.

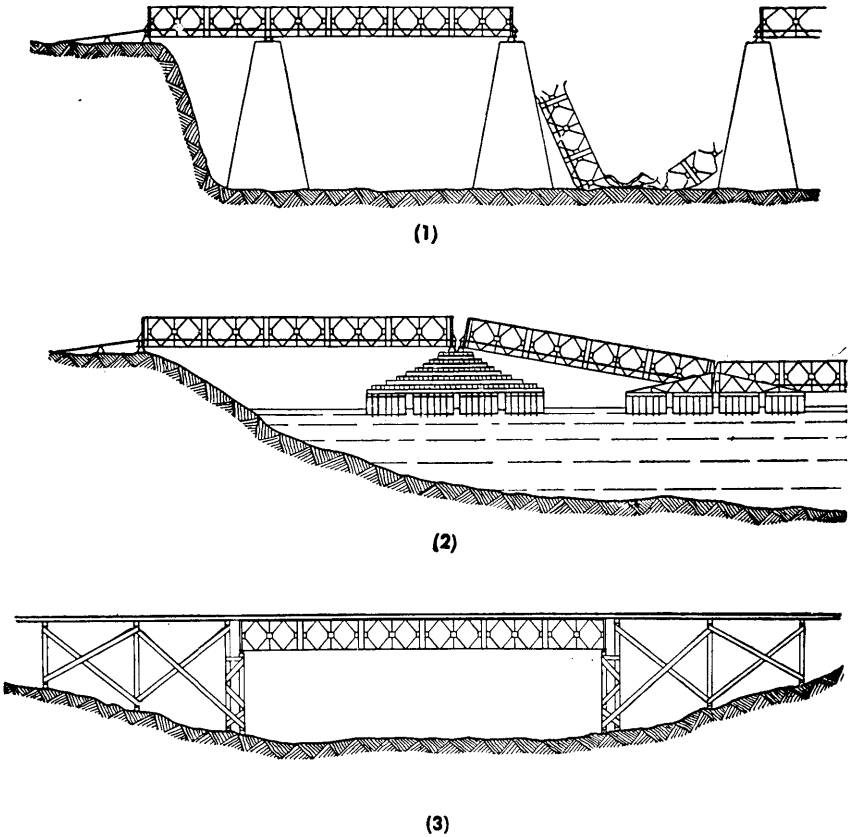
(2) It is lowered or slid into position and then the next girder is launched.

(3) Standard sway braces, transoms, stringers, and decking, or expedient bracing and flooring are added to complete the bridge.

d. METHODS OF LAUNCHING. Single-truss girders may be launched with gin poles or high line. Multitruss girders may be launched by any one of the following methods (par. 279):

(1) Counterweight.

(2) Launching nose.

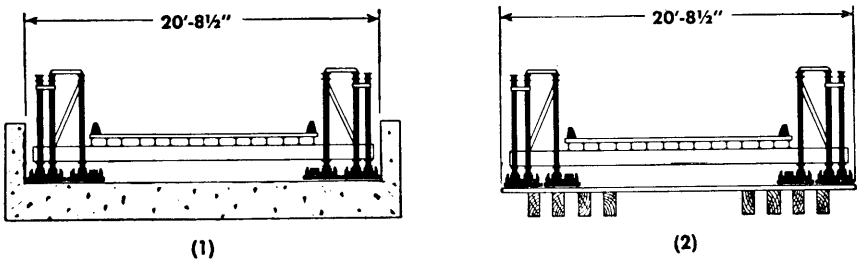


(1) *Damaged span of multispan panel bridge. Piers are wide enough to take ends of new span but existing bridge is not wide enough to launch new span complete.*

(2) *Intermediate landing bay of floating panel bridge in tidal water. Launching is to point much lower or of varying height.*

(3) *Deck type panel bridge.*

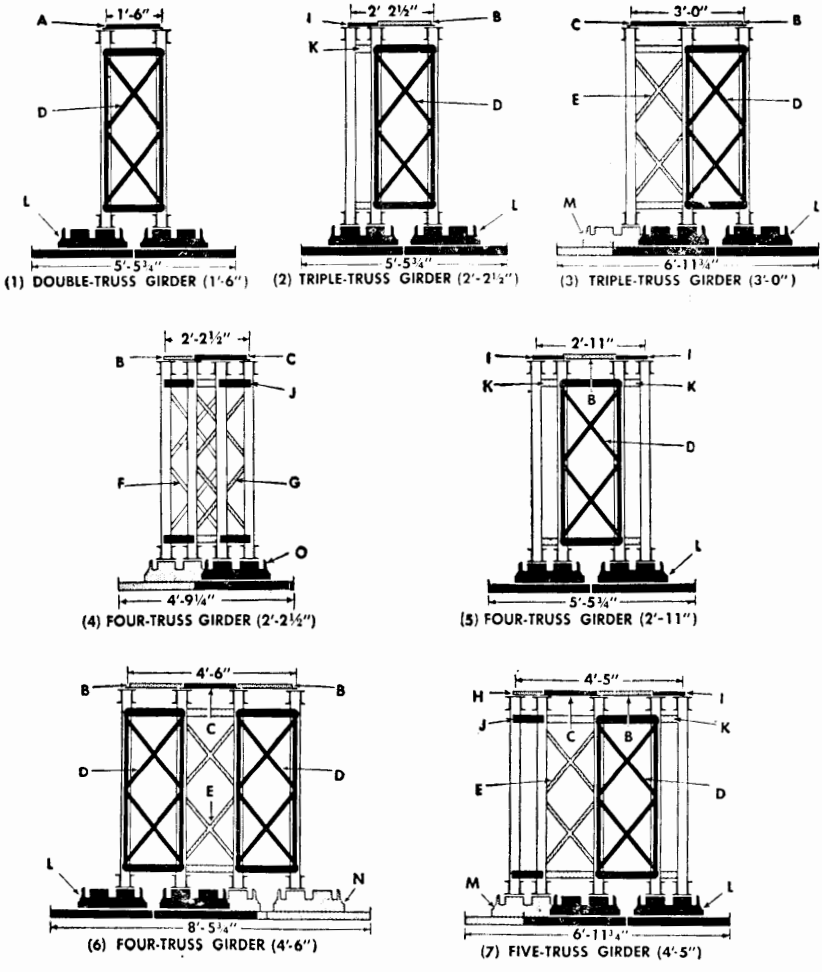
Figure 313. Situations where single-girder launching may be used.



(1) *Launching panel bridge from civilian through-type bridge.*

(2) *Launching panel bridge from deck-type bridge.*

Figure 314. Necessary clearances for launching panel bridge from existing bridge.



KEY

BRACING FRAMES

A ON TOP OF EVERY PANEL
B ON TOP OF EVEN NUMBERED PANELS
C ON TOP OF ODD NUMBERED PANELS
D ON FRONT END OF EVERY PANEL
E ON BACK END OF EVERY PANEL
F ON BACK END OF EVEN NUMBERED PANELS
G ON BACK END OF ODD NUMBERED PANELS

TIE PLATES

H ON TOP OF EVEN NUMBERED PANELS
I ON TOP OF ODD NUMBERED PANELS
J ON FRONT END OF EVERY PANEL
K ON BACK END OF EVERY PANEL

PLAIN ROLLERS

L TWO ROLLERS ON TEMPLATES PLACED BACK-TO-BACK
M THIRD ROLLER AND TEMPLATE BEHIND FIRST PAIR OF ROLLERS
N SECOND PAIR OF ROLLERS AND TEMPLATES BEHIND FIRST PAIR
O TWO ROLLERS ON TEMPLATES STAGGERED ONE BEHIND THE OTHER

Figure 315. Multitruss girders and arrangement of plain rollers for launching.

(3) Gin pole and snubbing tackle.

(4) High line.

e. WORKING PARTIES. Size of working parties varies with size of girder. To assemble girders, men are divided into panel parties, pin parties, and bracing parties. They combine to launch the girders. After girders are in place, the men are divided into bracing and flooring parties to complete the bridge.

f. LIMITATIONS. (1) Launching by single girders takes longer than the normal method of launching panel bridges.

(2) A girder is always launched as a single-story girder. Additional trusses or stories are added after the girder has been launched.

(3) Bracing frames between trusses prevent overturning and give the girder rigidity. However, when launching long girders with counterweight or launching nose, the end is subject to considerable whipping. In a cross wind, a 150-foot double-truss girder (for a 75-foot gap) may swing 6 inches at the nose.

(4) Plain rollers must be placed under every truss to support the girder evenly and prevent twisting.

(5) For limitations of individual launching methods, see paragraph 279.

277. Lay-out of Rollers

a. TYPE. Both plain and rocking rollers are used.

b. SETS. (1) Plain rollers are used in sets under the girder, so each truss rests on a roller. In some cases, plain rollers must be staggered to prevent interference between rollers. Figure 315 shows the arrangement of plain rollers in sets under the girder.

(2) Rocking rollers cannot be staggered. When trusses are spaced 1 foot 6 inches on centers, rocking rollers are placed under every truss. When two outer trusses are spaced 8½ inches on centers by tie plates, a single rocking roller is placed under the inner of the two trusses (fig. 316). Under the four-truss (2′ 2½″) girder, the rocking rollers are placed under the outer trusses (fig. 317).

c. LAY-OUT OF SETS. (1) Rocking rollers are used at the edge of the gap and plain rollers are placed at about 25-foot intervals back along the girder. (See fig. 318.) With double-truss girders, plain rollers can be used instead of rocking rollers at the edge of the gap.

(2) When using a counterweight or launching nose, the girder is assembled and launched on the side of the existing bridge nearest its final position. (See fig. 321.) A second girder is erected simultaneously at the other side of the deck of the existing bridge. Rollers are laid out accordingly.

(3) When using a gin pole and snubbing tackle, two gin poles, or a high line, rollers are laid out so the girder is assembled and launched along the center line of the bridge.

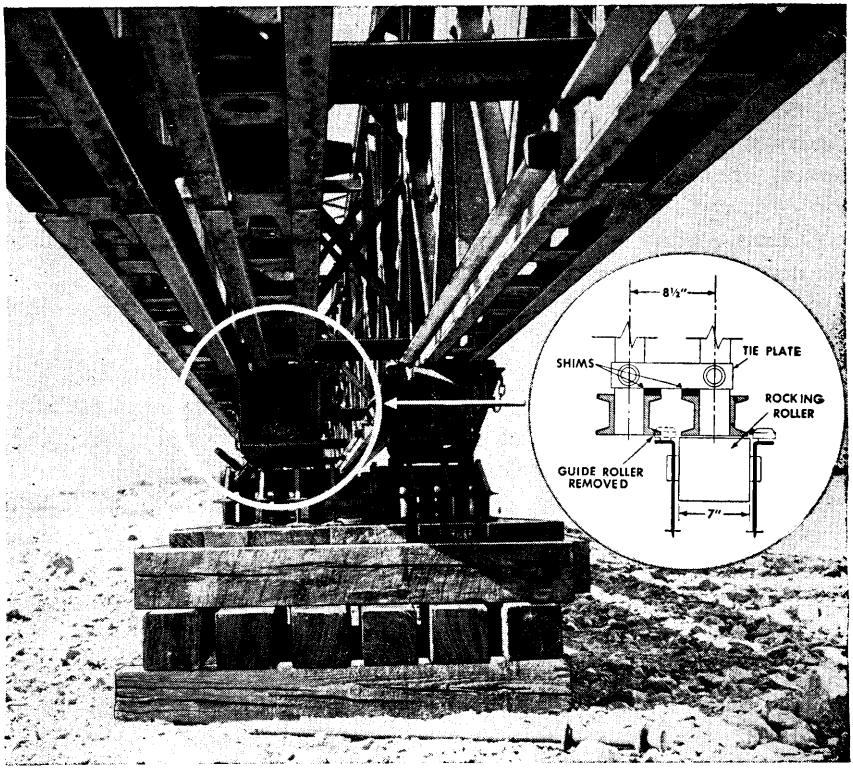


Figure 316. Arrangement of rocking rollers under a triple-truss (2'2½") girder. Inset shows two trusses spaced 8½ inches on centers. Outer guide roller is removed. Shims are wedged between tie plate and chord-channel flanges to prevent outside truss from slipping down.

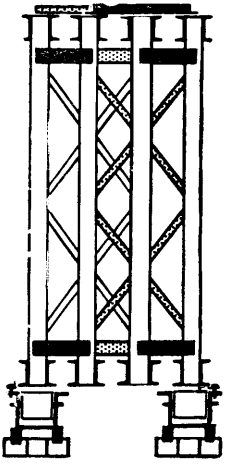


Figure 317. Arrangement of rocking rollers under four-truss (2'2½") girder.

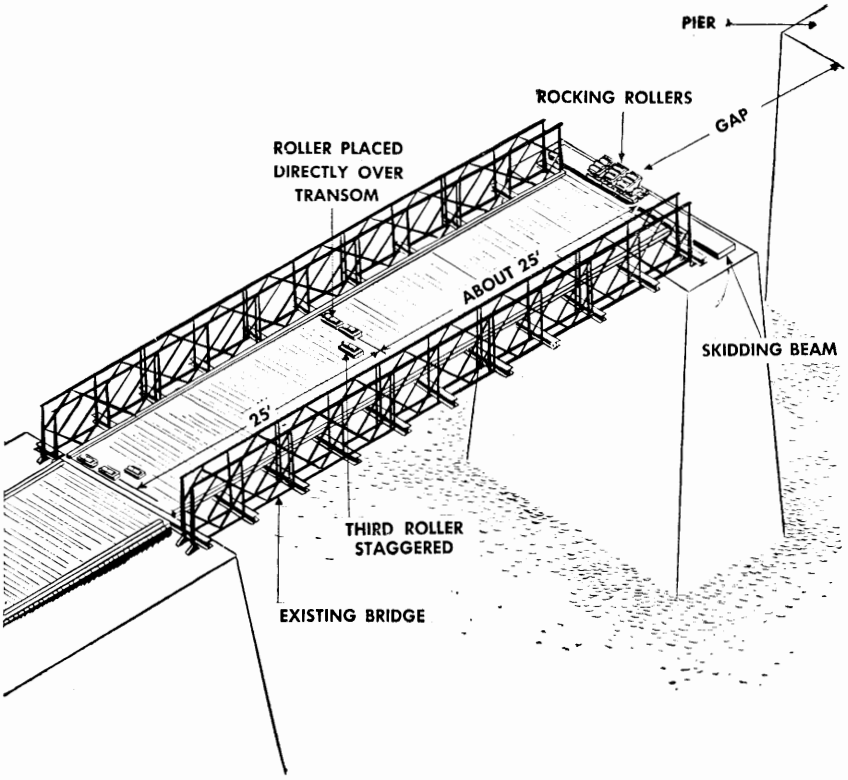


Figure 318. Lay-out of launching rollers for launching triple-truss (5'0") girder from existing panel bridge.

(4) When launching from an existing panel bridge, all plain rollers are placed directly over transoms to avoid overstressing stringers. (See fig. 318.) Rocking rollers are preferably set on cribbing directly on the pier. If it is necessary to place the rocking rollers on the deck of the existing panel bridge, they are placed directly over the end transom. If the total launching weight on the rocking rollers is greater than 14 tons, two transoms are used under the rollers; if the launching weight is greater than 28 tons, cribbing is wedged under the center of the end transoms.

278. Assembling Girder

a. The girder may be made up of from one to five trusses. (See fig. 315.)

b. Trusses of multitruss girders are connected on every possible place by bracing frames and tie plates across the top chords and ends of panels. (See fig. 315.) All tie-plate bolts must be tight and shims must be used to prevent the outer truss slipping down when the end

of the girder is over the gap. (See fig. 316.) In girders with the outer trusses spaced 8½ inches, the panel pins connecting the nose to the main girder are inserted from the inside so the nose can be disconnected after launching. (See fig. 319 and 322.) In all other cases in both the main girder and the nose, the pins are inserted from the outside toward the center line of the girder.

c. End posts are placed on the front end of all trusses before launching, except when a launching nose is used, in which case the front end posts are placed after the girder has been launched. Rear end posts are placed when the girder is in position for jacking down.

d. Table 78 lists the parts required to assemble each type of girder.

Table 78. Parts Required to Assemble Single and Multitruss Girders

Item	Number of parts per two bays							
Number of trusses	One	Two	Three	Three	Four	Four	Four	Five
Spacing of outer trusses		1′–6″	2′–2½″	3′–0″	2′–2½″	2′–11″	4′–6″	4′–5″
Bolt, bracing		16[2]	24	24	32[4]	36	36[2]	48
Frame, bracing		4[2]	3[3]	6	4[4]	3[3]	9[2]	6
Panel	2	4	6	6	8	8	8	10
Pin, panel[1]	4	8	12	12	16	16	16	20
Plate, tie			6		8	12		12
Post, end	Add one end post at each end of each truss.							

[1] Add two panel pins at end of each truss.
[2] Add one bracing frame and four bracing bolts in last bay.
[3] Add one bracing frame in last bay.
[4] Delete one bracing frame and four bracing bolts from last bay.

279. Launching Girder

a. Counterweight Method (fig. 320). (1) A counterweight is added to the rear end of the girder to balance the front end of the girder as it is pushed on rollers out over the gap. Long girders may be kept in line by using side guys and a pull winch from the far pier. When across the gap, the front end lands on rollers at the far bank or pier, or on the landing-bay pier of a floating bridge. The counterweight is then disconnected, rear end posts are attached, rollers at each end are removed, and the girder is jacked down onto skidding beam.

(2) Girders may be counterweighted either by adding weights to the last bay of a short tail on the girder or by making the girder of the same construction and twice as long as the span so the tail alone will counterbalance the span. Table 79 lists weights needed on short tails to counterweight various spans of multitruss girders. If the long

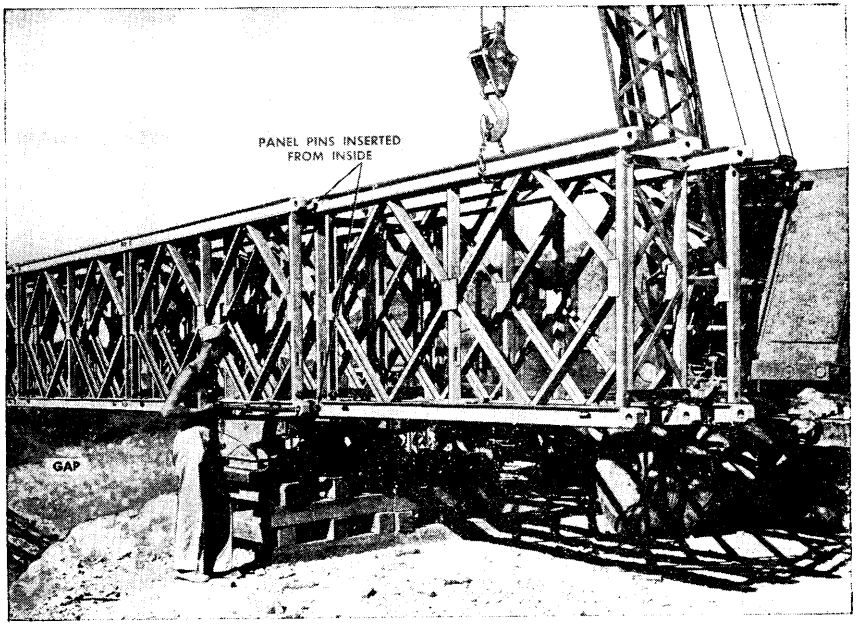


Figure 319. Dismantling triple-truss nose from five-truss girder. Note that panel pins have been inserted from the inside at the connection between the nose and girder so that they can be removed by using a bar to drive them toward the center of the girder.

tail is used, it may be disconnected after the first girder is launched, and used for a second girder.

(3) The counterweight method is useful when site conditions at the far side prevent use, removal, or disposal of a launching nose, or erection of a gin pole or high line. When launching long girders of a deck type bridge, a counterweight permits tipping the far end directly onto the pier without jacking down.

b. Launching-nose Method (fig. 321). (1) A lightweight launching nose is attached to the front end of the girder, and the girder with nose is pushed on rollers out over the gap. To compensate for sag, launching-nose links may be used in the same manner as when launching the normal panel bridge. Long girders may be kept in line by using side guys and a pull winch. When across the gap, the nose lands on rollers on the far bank. It is then disconnected, front end posts are attached, rollers at each end are removed, and the girder is jacked down onto skidding beams.

(2) Table 80 lists the types and lengths of noses needed to launch multitruss girders. Single-truss girders cannot be launched by this method. Launching noses are braced the same as the girder. When launching the triple-truss girder with an eccentric double-truss nose,

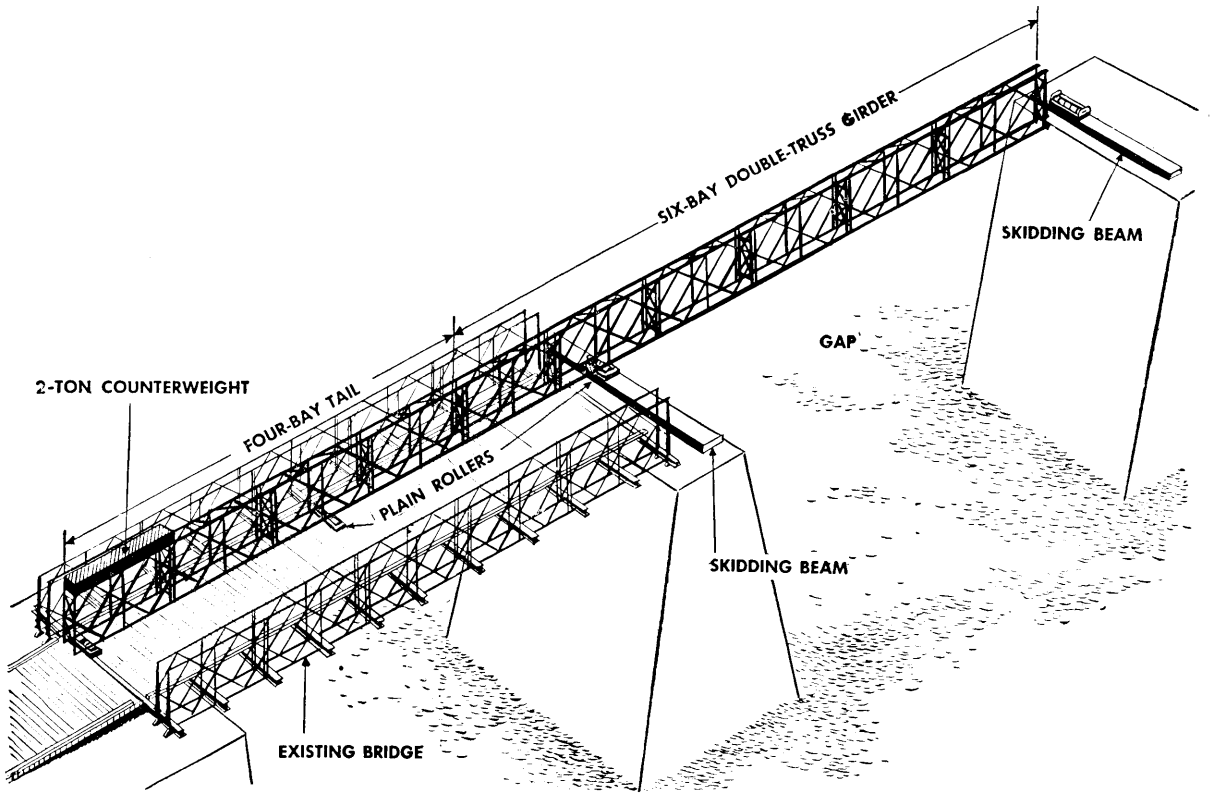


Figure 320. Launching single girder with counterweight. See table 79 for the length of tail and counterweight needed with various spans.

the nose must be dismantled bay by bay as it passes over the landing rollers. Otherwise, the nose beyond the landing rollers twists the girder, and may cause failure.

(3) The launching-nose method is used for longer girders, where sag is appreciable. It can also be used for girders too heavy for a gin pole or high line. Launching by this method is easier than with a counterweight, because the girder with nose is lighter than the girder with counterweight.

Table 79. Required counterweight for Various Spans of Multi-Truss Girders[1]

Span (feet)[1]	Number of bays in tail	Counterweight (tons)[2]	Total weight on rocking rollers (tons)
	Double-truss girder and tail		
40	3	1.1	5.6
50	3	2.3	7.5
60	4	2.0	8.6
70	4	3.5	10.4
80	5	3.0	11.4
90	5	4.2	13.3
	Triple-truss girder and tail with outer trusses spaced 2'2½"		
40	3	1.6	8.3
50	3	3.3	10.9
60	4	2.9	12.4
70	4	4.8	15.1
80[3]	5	4.4	16.5[3]
90[3]	5	6.2	19.3[3]
	Triple-truss girder and tail with outer trusses spaced 3'0"		
40	3	1.7	8.5
50	3	3.5	11.3
60	4	3.0	12.7
70	4	4.9	15.6
80	5	4.4	17.0
90	5	6.3	19.9

[1] Longer spans cannot be launched by this method because of insufficient lateral stability.

[2] Counterweight added to last bay of tail.

[3] Use plain rollers for launching. Place one roller under each truss.

Table 79. Required counterweight for Various Spans of Multi-Truss Girders[1] *—Continued.*

Span (feet)[1]	Number of bays in tail	Counterweight (tons)[2]	Total weight on rocking rollers (tons)
Four-truss girder and tail with outer trusses spaced 2′2½″			
40	3	2.1	11.0
50	3	4.5	14.7
60	4	3.9	16.5
70	4	6.4	20.3
80	5	5.9	22.2
90	5	8.2	25.8
Four-truss girder and tail with outer trusses spaced 2′11″			
40	3	2.1	11.0
50	3	4.4	14.4
60	4	4.0	16.5
70	4	6.3	20.1
80	5	5.8	22.0
90	5	8.2	25.7
Four-truss girder and tail with outer trusses spaced 4′0″			
40	3	2.2	11.4
50	3	4.6	15.1
60	4	4.1	17.2
70	4	6.6	21.0
80	5	6.1	23.0
90	5	8.5	25.7
Five-truss girder and tail			
40	3	2.7	13.9
50	3	5.6	18.4
60	4	5.0	20.8
70	4	8.0	25.5
80	5	7.4	28.0
90	5	10.3	32.4

[1] Longer spans cannot be launched by this method because of insufficient lateral stability.

[2] Counterweight added to last bay of tail.

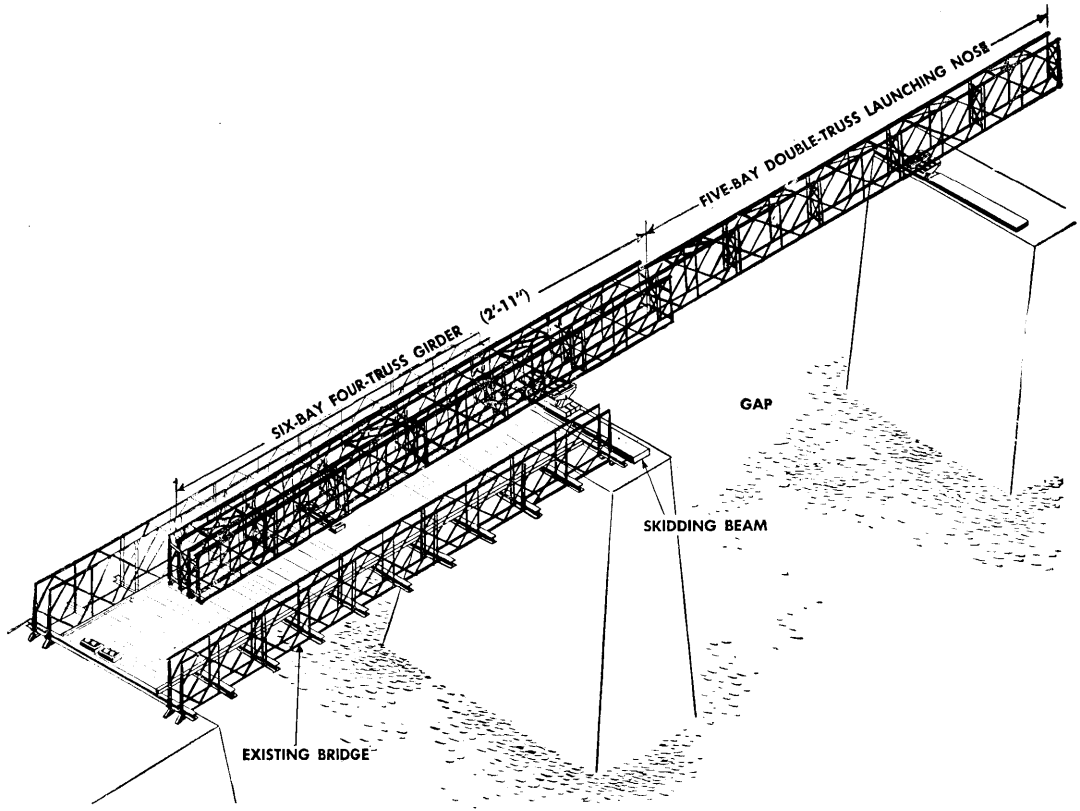
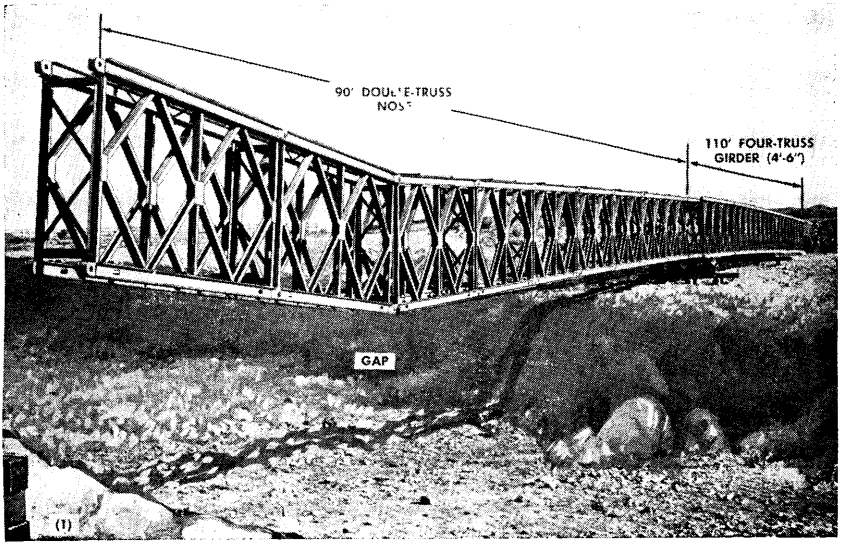
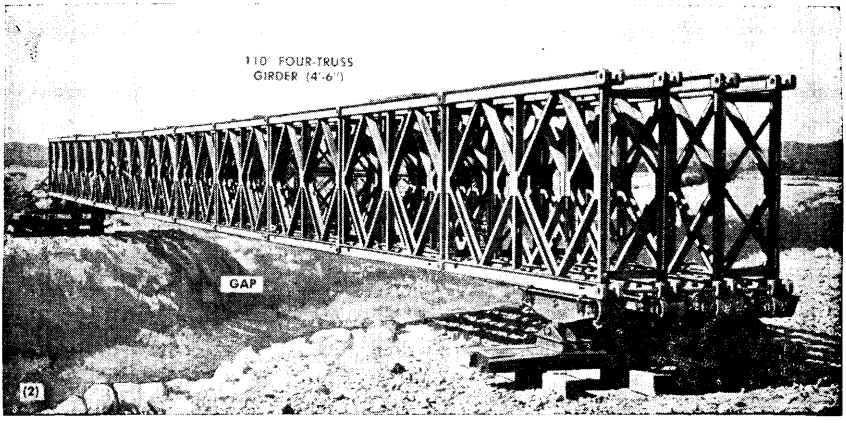


Figure 321. Launching four-truss girder with launching nose. See table 80 for the length of nose needed with various spans.



(1) *Launching a 110-foot four-truss girder (outer trusses spaced 4 feet 6 inches) with a 90-foot double-truss nose.*

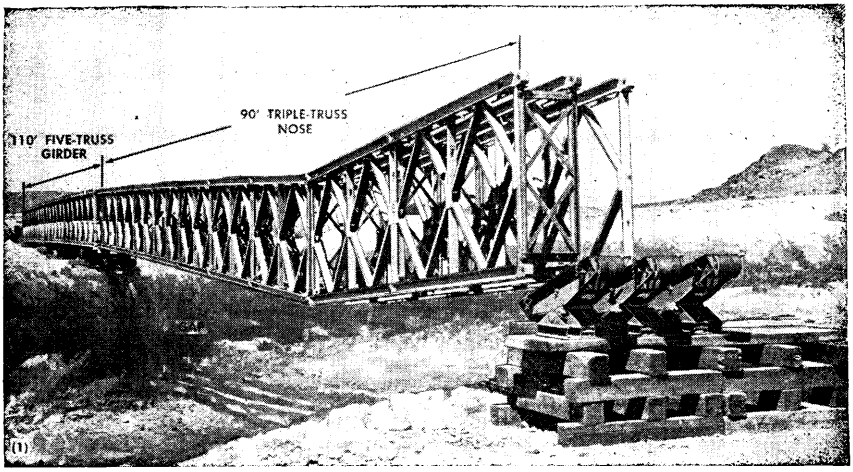


(2) *A 110-foot four-truss girder completely launched.*

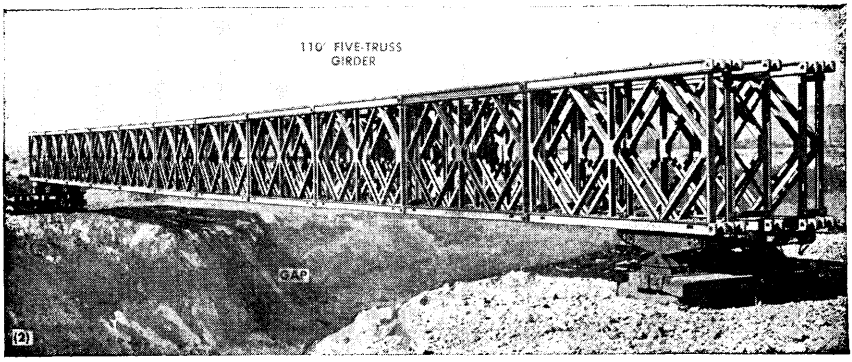
Figure 324.

keeping the snubbing line taut to prevent too rapid movement. When the girder has passed its balance point, it is allowed to dip about one-tenth of its length to lessen stress in the tackle. After the girder is across the gap, the gin pole and the truck-mounted crane lift it directly onto the bearings.

(2) When a truck-mounted crane is not available, two gin poles may be used, one on each bank. Both gin-pole lines are attached to the front end of the girder, which is pulled over the gap by taking up on



(1) *Launching a 110-foot five-truss girder with a 90-foot triple-truss nose.*



(2) *A 110-foot five-truss girder completely launched.*

Figure 325.

the far gin-pole line and slacking off on the near gin-pole line. When the front end of the girder is over the far bank, the line from the near gin pole is changed from the front to the rear end of the girder, which is then lowered onto its bearings.

(3) This method is better for short spans, since long girders are heavy and difficult to handle. It also saves bridge equipment, because it eliminates the need for either a launching nose or counterweight. In addition to handling girders, the gin pole and truck-mounted crane can be used to "telegraph" transoms and decking into place. (See par. 282*a*(2).)

d. Direct-lift Method (fig. 327). (1) The girder is assembled on the ground beside the piers. Two cranes or gin poles lift the girder into place on the piers. In case of water gap, the girder may be floated out to the piers and lifted into place by cranes on rafts or on the

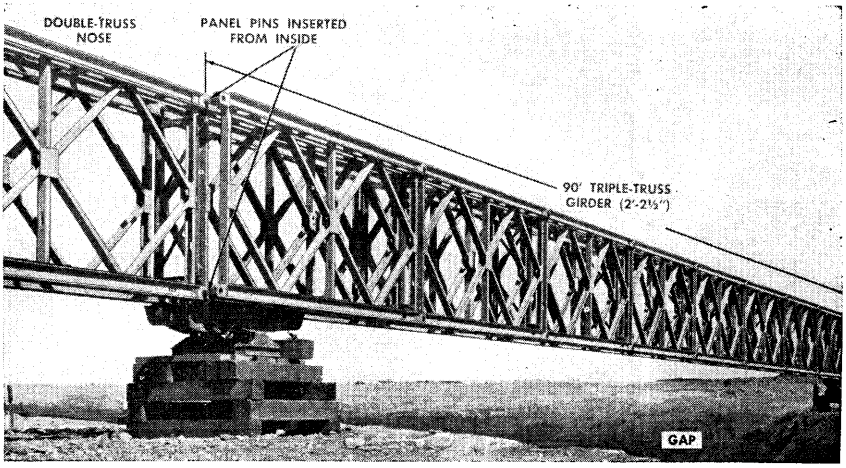


Figure 322. Launching a 90-foot triple-truss girder (outer trusses spaced 2 feet 2½ inches) with an 80-foot double-truss nose.

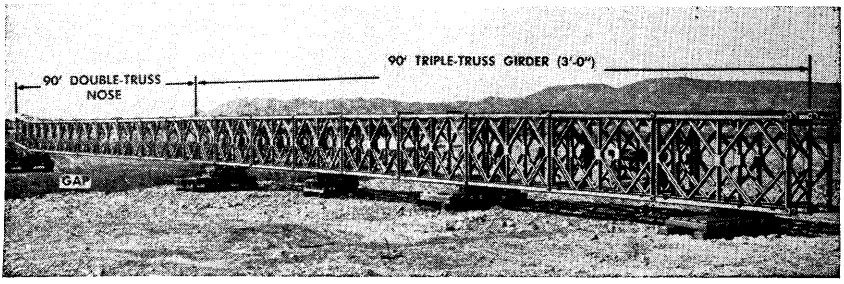


Figure 323. Launching a 90-foot triple-truss girder (outer trusses spaced 3 feet 0 inches) with a 90-foot double-truss nose.

c. Gin-pole and Snubbing Tackle Method (fig. 426). (1) A gin pole is erected at the far bank or pier. Tackle is rigged from the gin pole to the front end of the girder with the fall line running to the winch of a truck on the bridge or bank. When a truck-mounted crane or tractor is used at the tail of the girder, the fall line is led around it by a snatch block at the side of the bridge. For long, heavy girders, guy lines are attached near the center of the girder on each side and controlled by winches on trucks to each side of the bridge. The girder rides on rollers on the near bank. It is braked by snubbing tackle attached to the rear end of the girder. When a truck-mounted crane is used at the rear of the girder, the hoist line is attached to the top of the rear end of the girder to keep it upright and to lift it onto the bearings. Power applied to the hauling winch pulls the girder across the gap. The truck-mounted crane moves forward with the girder,

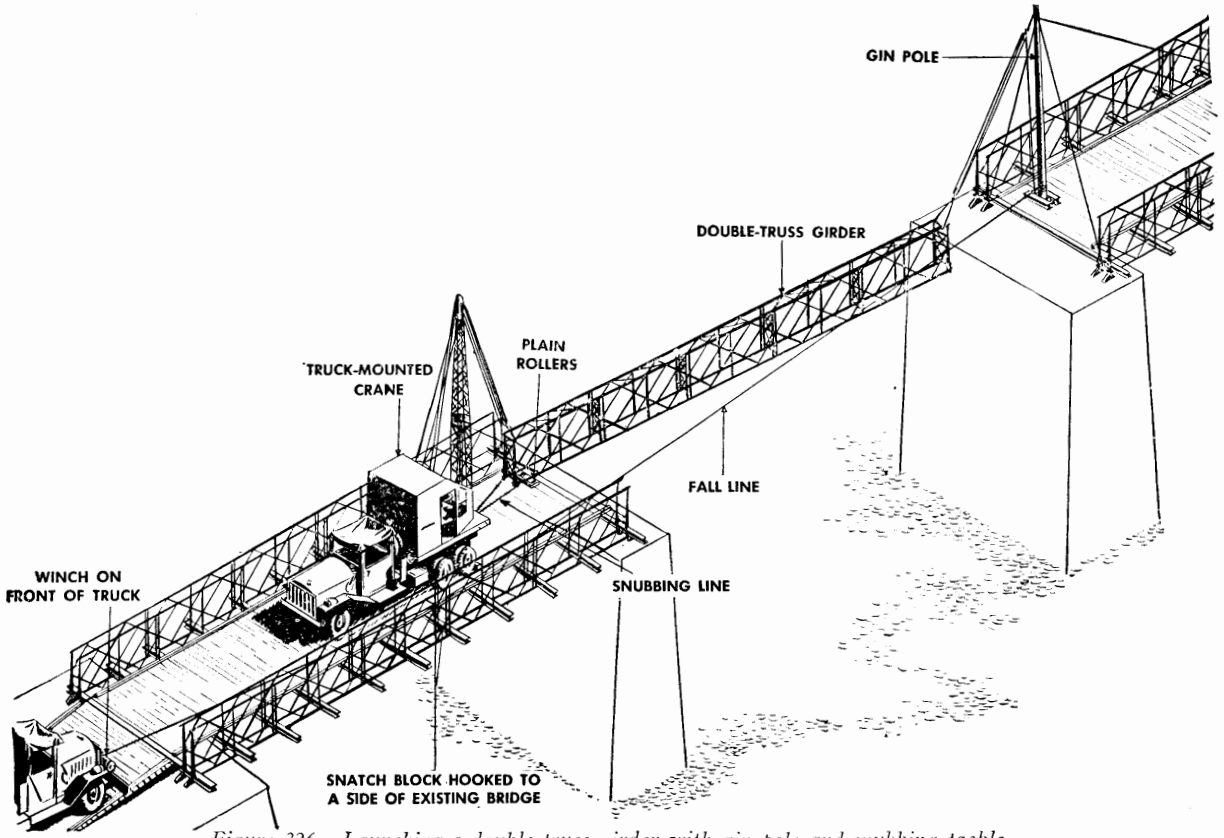


Figure 326. Launching a double-truss girder with gin pole and snubbing tackle.

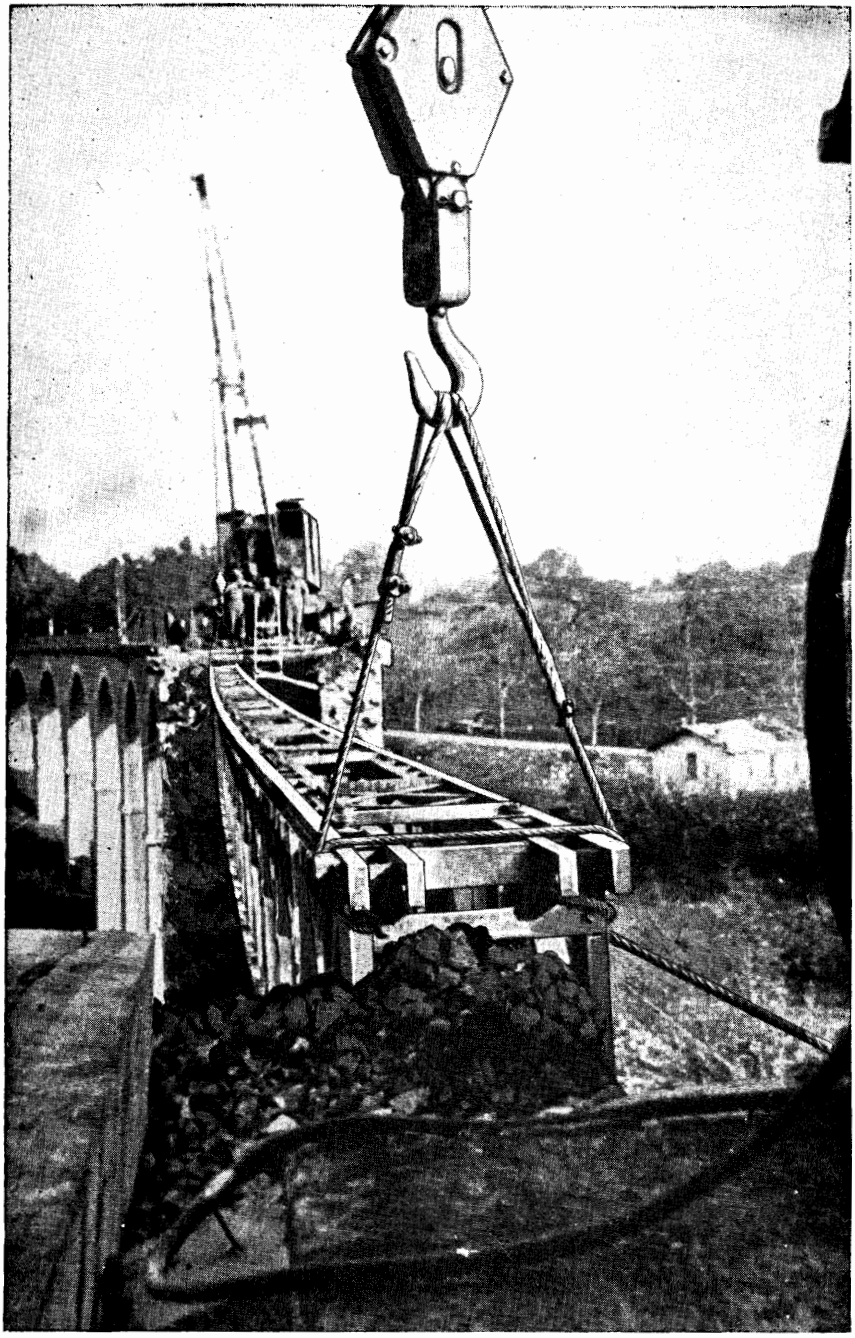


Figure 327. Two cranes lifting a 120-foot double-truss girder into place in deck railway bridge at Sisteron, France.

piers. Cranes are not needed if the piers are low enough so the girder can be floated into place and lowered onto the piers by pumping water into the raft pontons as illustrated in figure 332.

(2) The length of girder that can be launched by this method is limited by capacity of the cranes. If the girders are short and light, a single crane can be used.

e. HIGH-LINE METHOD (fig. 328). (1) A high line of suitable capacity is rigged across the gap along the center line of the bridge. The girder is suspended from the high line, pulled over the gap, and lowered onto skidding beams. The trolleys on the high line are attached to slings on the girder near the quarter points. The girder is rolled on the approach span to its balance point on the first roller before being carried by the high line. Tag lines at both ends of the girder are used to control it during launching.

(2) This method is useful for launching deck type bridges where the girder has to be lowered a considerable distance to the skidding beams. In addition to handling the girders, the high line can be used to carry out the transoms and decking; and where trestle approach spans are used, it can be used to carry out bridge parts for the approach spans. This method also eliminates the need for either a launching nose or counterweight. The capacity of high lines is usually limited to short single- or double-truss girders. Table 81 lists the weights of various lengths of girders.

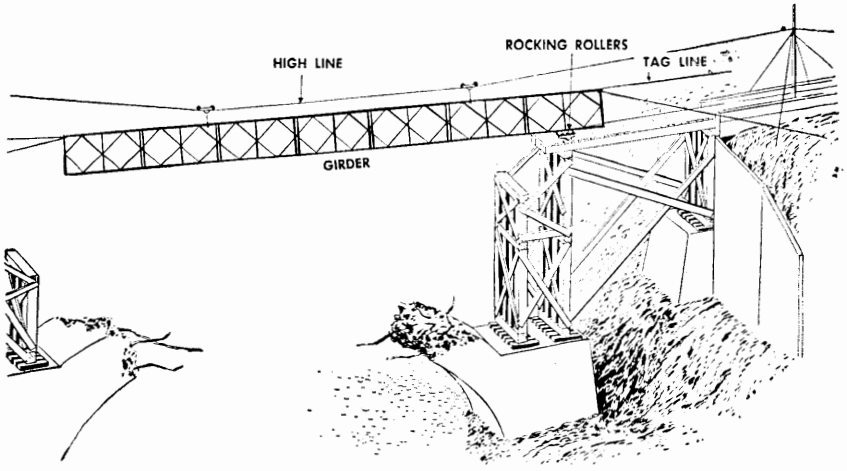


Figure 328. Launching single-truss girder with a high line.

280. Jacking Down

The girders are jacked down either with a jack under each end post or with jacks under an equalizing beam supporting the underside of the girder. (See fig. 329.) The jacks should be operated in unison so the

girder is lowered evenly. During the lowering, the girders should be guyed to prevent overturning. Place cribbing under bottom chords or equalizer beam to prevent girder from dropping if it slips off the jacks. If the distance to be lowered is great, the girder is lowered by successive stages. When truck-mounted cranes or gin poles are available at each end of the bridge, the girders are lowered directly on the bearings.

*Table 81. Weight of Single-Truss and Multitruss Girders**

Span (feet)	Weight (tons)							
Number of trusses	One	Two	Three	Three	Four	Four	Four	Five
Spacing of outer trusses	—	1′6″	2′2½″	3′0″	2′2½″	2′11″	4′6″	4′5″
30	0.9	1.9	2.8	2.8	3.7	3.7	3.8	4.7
40	1.2	2.5	3.7	3.8	4.9	4.9	5.1	6.2
50	1.5	3.2	4.6	4.8	6.2	6.1	6.4	7.8
60	1.8	3.8	5.5	5.7	7.4	7.4	7.7	9.3
70	2.1	4.4	6.5	6.7	8.7	8.6	9.0	10.9
80	2.4	5.1	7.4	7.6	9.9	9.8	10.3	12.5
90	2.6	5.7	8.3	8.6	11.1	11.1	11.5	14.0
100	2.9	6.4	9.3	9.5	12.4	12.3	12.8	15.6
110	3.2	7.0	10.2	10.5	13.6	13.5	14.1	17.1
120	3.5	7.6	11.1	11.4	14.8	14.7	15.4	18.7

* Without end posts.

281. Skidding Girder into Position and Squaring Up

a. After launching, the girder is moved into position by truck cranes, or skidded into position on greased skidding beams by prying with panel levers or pinch bars. (See fig. 330.) Panel-bridge stringers are preferred for skidding beams, but I-beams or timber beams may be used.

b. After the first girder is lined up with the existing bridge, the second girder is squared up with the first. If the trusses cannot be moved in a longitudinal direction without rollers, rollers are reinserted after skidding.

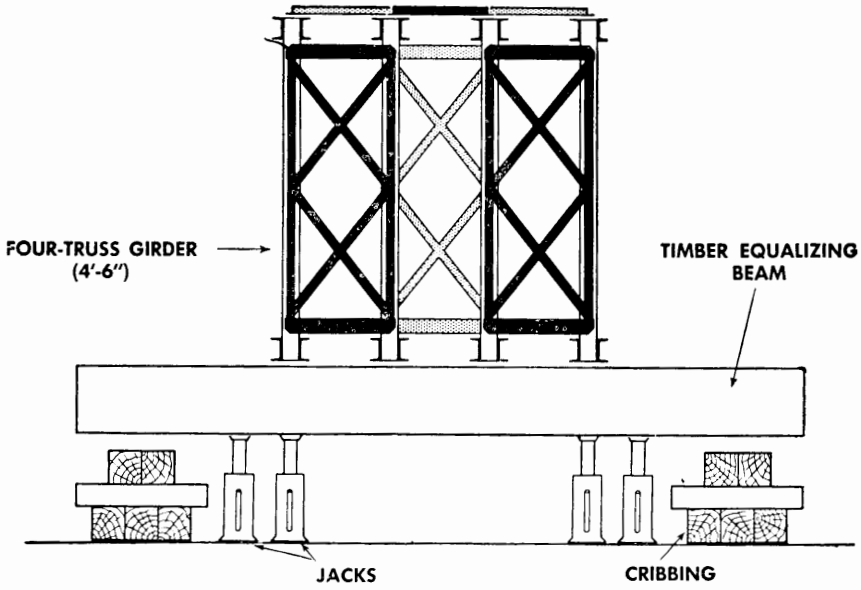


Figure 329. Jacks under four-truss girder using equalizing beam.

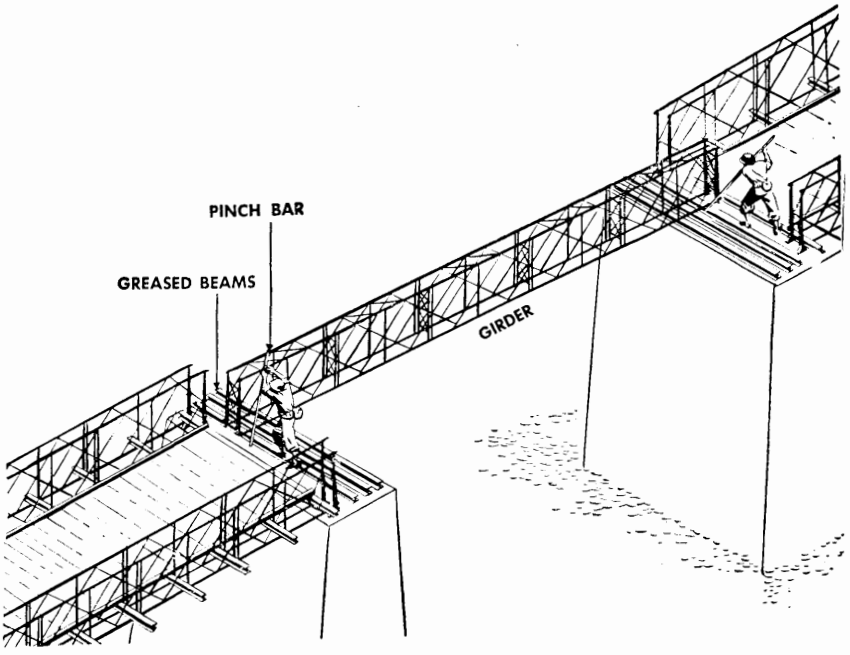


Figure 330. Skidding girder into place by prying with pinch bars.

282. Completing Bridge

a. NORMAL THROUGH-TYPE CONSTRUCTION. The bridge is completed bay-by-bay working out from the near shore in the following sequence:

(1) Insert sway braces of first bay with adjusting collars on same side of bridge. Two lashings from centers of bottom brace are used to hold center of sway braces up until ends have been pinned in place. Do not tighten.

(2) Place transoms in first bay. A truck mounted crane with gin pole on far bank may be used to "telegraph" transoms into place, or they may be placed by hand. In the "telegraph" method, a line from the gin pole on the far bank and a line from the crane on the near bank are both attached to the transom. The transom is then picked up and placed by taking up the gin-pole line and slacking off on the crane line. A tag line on the transom is used to guide it. For further details see TM 5–285. When handled manually, the transom is pushed out from the bank and swung into position with the aid of ropes attached to the top chords. The transoms are difficult to fit at first, but this becomes easier as more bays are completed.

(3) Place stringers in first bay.

(4) Remove vertical bracing frames and insert rakers. Do not tighten.

(5) Repeat above procedure to install sway braces, transoms, stringers, and rakers in second bay.

(6) After bracing members are inserted in second bay, tighten all bracing in first bay and lay chess and ribands in first bay.

(7) Remainder of decking is added in the same manner.

(8) Install ramps.

b. DECK-TYPE BRIDGE. These are decked either with standard panel-bridge flooring or with expedient timber decking. For details of deck-type bridges, see chapters 22 and 23.

CHAPTER 30

LAUNCHING WITHOUT ROLLERS

283. General

Single-single bridges up to 40 feet long can be launched by manpower without rollers by skidding on greased beams.

284. Details

Greased timbers or greased stringers are placed at the edge of the gap and 20 feet back under each line of trusses. The bridge is built on the skids with one transom per bay and no stringers or chess. Three bays of tail are added with two transoms per bay and stringers in the last bay as a counterweight. The bridge is then pushed out over the gap with the aid of pinch bars and levers. Men on the far bank lift the front end onto blocking. The tail is removed, end posts are added, and the bridge is jacked down onto bearings. Second transom is added in each bay and decking and ramps are laid, completing the bridge. If end posts and bearings are not available, the ends of the bridge are supported as described in chapter 27.

CHAPTER 31

LAUNCHING BY FLOTATION

285. Scope

This chapter describes the method of launching a fixed panel bridge by floating the spans into position.

286. Advantages and Disadvantages

a. ADVANTAGES. (1) Large construction site not needed.

(2) Construction site can be away from center line of bridge.

(3) Launching nose or cantilever tail not needed.

b. DISADVANTAGES. (1) Gap must be water-filled with sufficient unobstructed depth to float loaded ponton.

(2) In stream current over 3 feet per second maneuverability of the rafts is difficult.

(3) Method takes longer than normal launching procedure.

287. Multiple Spans

a. INTERMEDIATE SPANS. Use pontons of suitable capacity under each end of the span to float it into position. Place cribbing on pontons to raise bridge so lower chord clears top of piers (fig. 331). Make sure bridge overhangs pontons at each end. This provides clearance for maneuvering between piers when floating span into position. Normally launch the bridge span on ponton rafts just downstream from the bridge site. Launching sequence for a typical 90-foot triple-single span on pontons is as follows (fig. 332):

(1) *Stage 1.* Construct far-shore raft with two pontons and enough cribbing to keep end of bridge above pier. Construct bridge on rollers on shore. Place launching rollers slightly higher than cribbing on raft.

(2) *Stage 2.* Push bridge on rollers until it rests on far-shore raft with enough overhang to insure clearance between raft and pier when span is in position over pier. Continue to push bridge and far-shore raft until end of bridge is near rocking rollers.

(3) *Stage 3.* Construct near-shore raft with four pontons and cribbing. Pump water into near-shore raft until it can be floated under shore end of bridge. If near-shore raft cannot be brought close inshore, place rocking rollers on cribbing on near-shore raft.

(4) *Stage 4.* When raft is in position under bridge, pump water out until lower chord of span is supported by cribbing or rocking rollers

(whichever is used) on raft. Continue pumping until span is raised clear of launching rollers on shore. If rocking rollers are used on raft cribbing, roll span into position and insert picket through lower chord of span and rocking roller to hold span in position.

(5) *Stage 5.* Maneuver raft into position between piers.

(6) *Stage 6.* Pump water into pontons until span is supported on piers (fig. 332). Remove rafts.

Note. Instead of pumping water into and out of the pontons to raise and lower the bridge, the same effect can be produced by using jacks on top of each raft. To raise the bridge, it is jacked up and more cribbing is inserted. To lower the bridge, it is jacked up, cribbing is removed, and the bridge is jacked down.

b. SHORE SPANS. (1) *Construction on center line.* Launch shore span from rollers on abutment along bridge center line. Place front of bridge on raft (fig. 333) and float out to seating on bent. Then jack up tail end, remove rollers, and jack bridge down on bearings. If end posts are not used and end panels of adjacent spans are connected by panel pins over the bent, cribbing may raise shore end of span too high and only top panel pins can be inserted to connect shore and intermediate spans. In that case, insert top pins and jack down shore end until bottom pins can be inserted. Then remove top pins and jack down shore span to bearings on abutment. Figure 334 shows a completed bridge of this type.

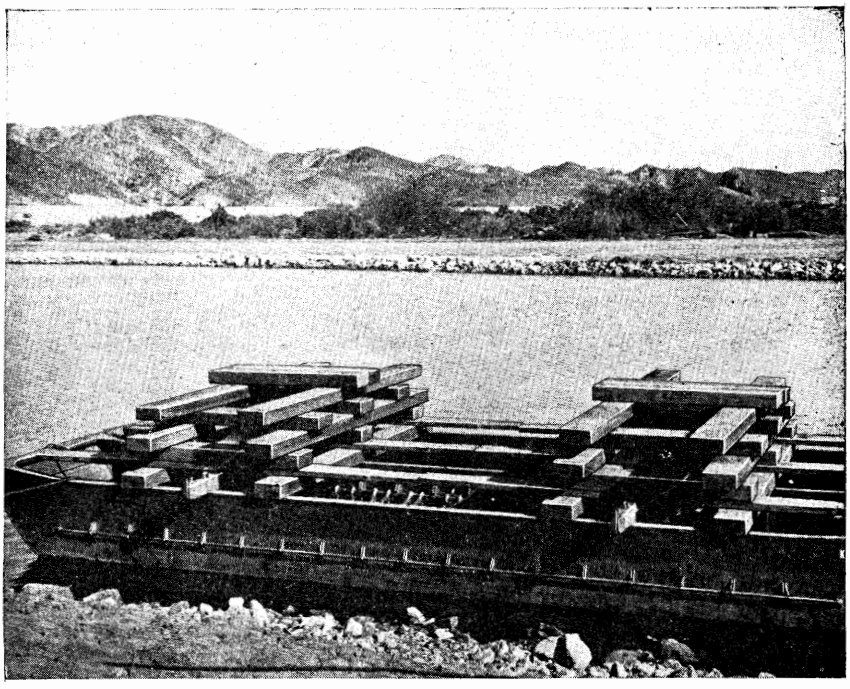


Figure 331. Cribbing on ponton raft to insure clearance between lower chord of bridge and top of pier.

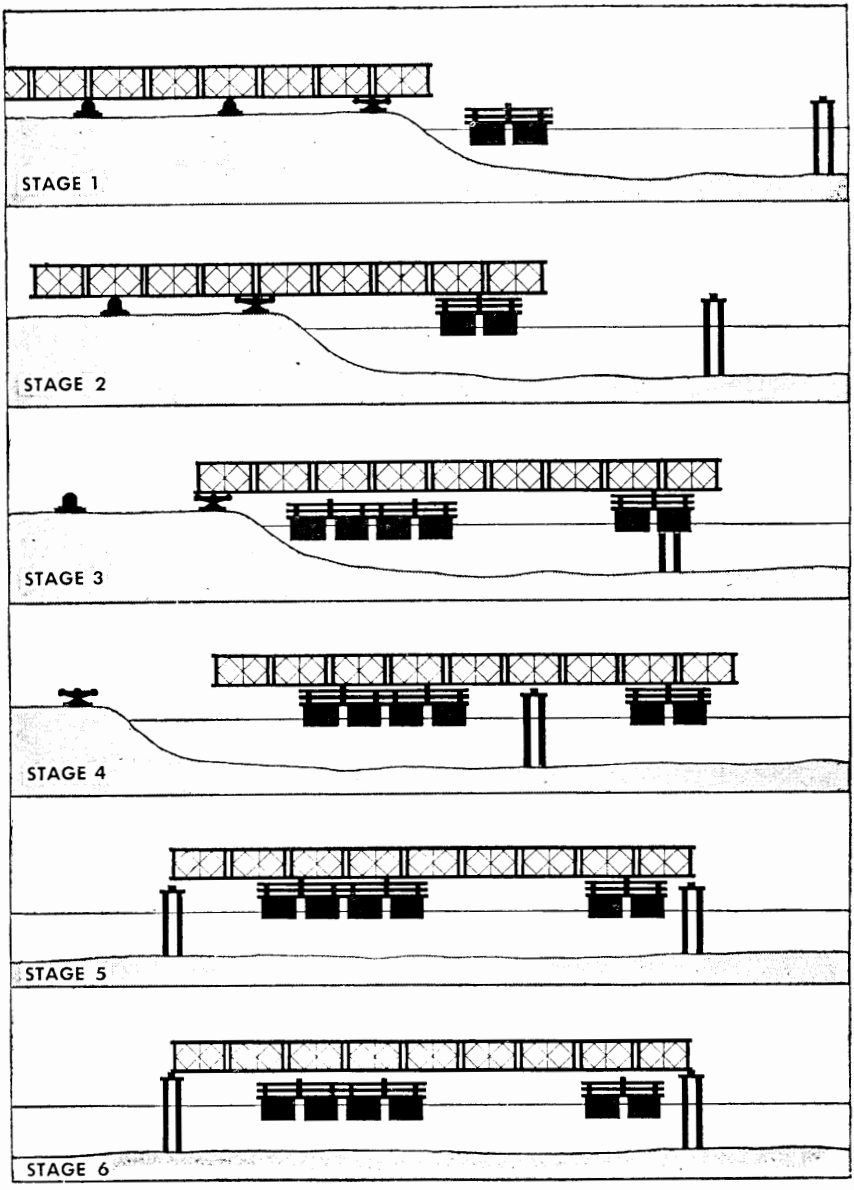


Figure 332. Stages of launching intermediate span by flotation. Stage 1. Construct bridge on rollers on near bank and prepare cribbing on far-shore ponton raft. Launching site is off final center line of bridge. Stage 2. Push bridge on rollers until it rests on far-shore raft. Continue pushing bridge and raft out until tail of bridge approaches last set of rollers. Stage 3. Prepare near-shore raft. Pump water into raft until it can be pushed under shore end of bridge. Stage 4. Pump water out of near-shore raft until bridge is lifted off rollers on shore. Stage 5. Maneuver bridge into position between piers. Stage 6. Pump water into pontons until bridge is supported on piers.

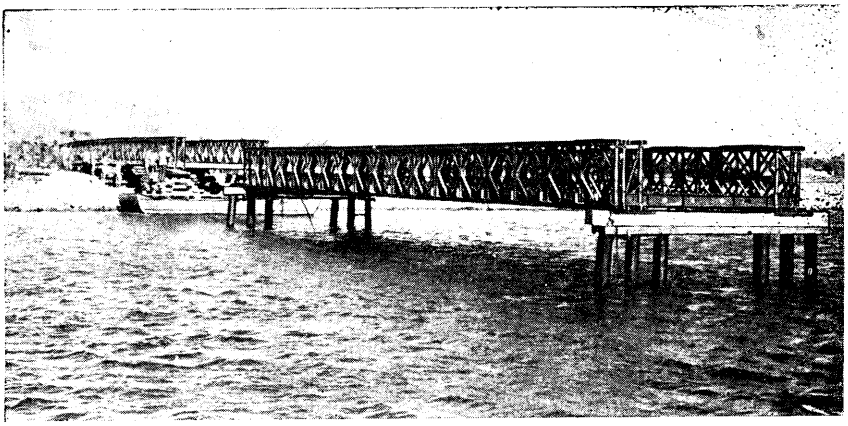


Figure 333. Intermediate span in position on pile bents. Front end of shore span on raft preparatory to floating shore span into position.

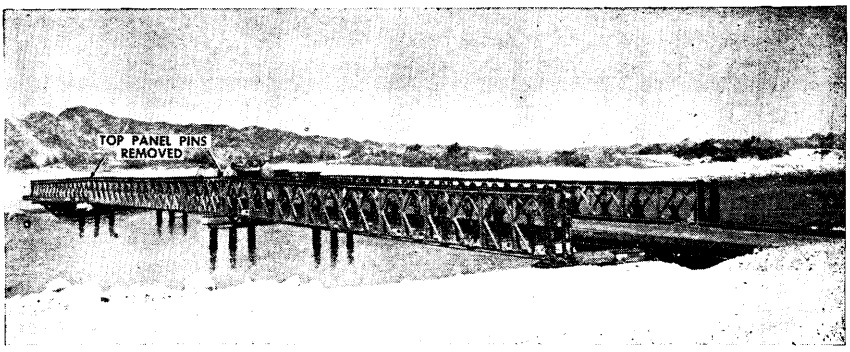


Figure 334. Broken-span bridge without end posts on intermediate pile bents.

(2) *Construction off center line.* Construct and launch shore span in same manner as intermediate span, floating it into position between abutment and first pier.

288. Single Span

a. CONSTRUCTION ON CENTER LINE. Float front end of bridge on raft across gap as bays of bridge are added at tail which is on rollers on near shore. Use enough cribbing on raft to keep front end of bridge above far-bank abutment. Launching links and a short upturned nose ahead of the raft can be used to raise the end high enough to clear the far-bank abutment (fig. 335).

b. CONSTRUCTION OFF CENTER LINE. Construct span off center line of bridge and launch on rafts. Float span into position between abutments and lower into place. Cribbing on rafts must keep bridge above abutments and overhang must be enough to prevent grounding of rafts.

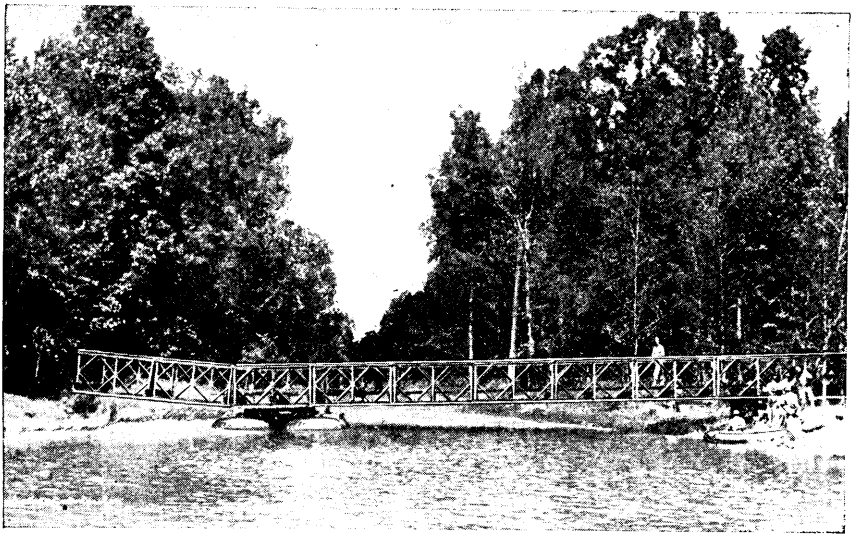


Figure 335. Launching a 110-foot DS panel bridge using pneumatic float raft under front end. Note use of launching links to raise end to clear far-bank abutment.

APPENDIX I

ASSESSMENT OF DAMAGE IN TERMS OF REDUCTION OF LOAD CLASSIFICATION

1. Scope

Appendix I gives a method of determining to what extent the capacity of a damaged bridge is reduced if the bridge remains open to traffic.

2. General Method

Capacity of damaged bridge is found by comparing the residual strength of a damaged member with the actual maximum stress it must take according to its position in the bridge.

3. Effect of Location of Damage

a. PANELS. Unit construction of the panel bridge produces girders of uniform section throughout their entire length. Many individual panel members are therefore not stressed to full capacity when the bridge is under maximum load. Only chords of the center bays and vertical and diagonal members of the end bays are fully stressed. Any damage to these members decreases the bridge capacity in direct proportion. Lightly stressed verticals and diagonals of the center bays, and chords of the end bays, can sustain considerable damage without affecting bridge capacity.

b. DECK AND BRACING MEMBERS. Since they can easily be replaced, the effect of damage to deck, transoms, sway braces, rakers, and bracing frames is not considered here.

Table 82. Residual Strength of Damaged Panel Verticals and Diagonals in Percent of Maximum Capacity of Full Section

						
100	85	70	50*	25	5	0

*When length of damage exceeds 6 inches, values must be reduced to 0.

Note: Darkened portion indicates damage.

4. Residual Strength of Damaged Panel Members

a. Verticals and Diagonals. Table 82 gives the residual strength of panel vertical and diagonal members expressed as percent of maximum capacity of the complete cross section. The figures apply to both tension and compression members.

Table 83. Residual Strength of Damaged Panel Chords in Percent of Maximum Capacity of Full Section

		DAMAGE TO NO 2 CHANNEL							
		1	2	3	4	5	6	7	8
DAMAGE TO NO 1 CHANNEL	1	100	50*	60	60	40*	55	55	5
	2	50*	50*	45*	45*	35*	30*	30*	0
	3	60	45*	40	60	30*	55	25	0
	4	60	45*	60	40	30*	25	55	0
	5	40*	35*	30*	30*	40*	15*	15*	0
	6	55	30*	55	25	15*	10	50	0
	7	55	30*	25	55	15*	50	10	0
	8	5	0	0	0	0	0	0	0

*When length of damage exceeds 15 inches, values must be reduced to 0.

Note: Darkened portion indicates damage.

b. CHORDS. Residual strength of damaged panel chords is given in table 83. The two channels of a panel chord act as one member. Damage to one channel is indicated in the left column of the table and damage to the other channel is shown in the top row. Combined result of damage to the two channels expressed as a percentage of the strength of the undamaged chord is found at the intersection of the appropriate column and row.

5. Shear and Moment Distribution

a. SINGLE-STORY BRIDGES. To simpify calculations, shear and moment in single-story bridges are assumed to be taken equally by all trusses.

b. DOUBLE-STORY BRIDGES. (1) *Shear.* Shear in double-story bridges is taken equally by both stories, except in end bays where the bottom story takes 60 percent of the total shear.

(2) *Moment.* Top and bottom chords of double-story bridges provide all resistance to bending. Damage to intermediate chords can be disregarded if it does not reduce shear capacity of web-member connections.

c. TRIPLE-STORY BRIDGES. (1) *Shear.* Shear is taken equally by all three stories of a triple-story bridge except in end bays, as follows:

(*a*) Only bottom and middle stories resist shear when deck is in the bottom story.

(*b*) Only middle and top stories resist shear when the deck is in the middle story.

(2) *Moment.* Stress in top and bottom chords of triple-story bridges is approximately three times that in intermediate chords. However, to simplify calculations, it can be assumed that top and bottom chords provide all bending resistance. Damage to intermediate chords causing loss of chord capacity up to 50 percent need not be considered, but cases of more extensive damage should be investigated and correlated with any damage in top or bottom chords of the same bay.

6. Shear and Moment Table

Table 84 gives maximum shear and bending moment in each bay of all spans of fixed panel bridges expressed as percentages of maximum capacity. Dead-load shear and moment values (DL) show percentage of shear and moment capacity of each bay required to support dead weight of the bridge itself. Live load values (LL) show percentage of shear and moment capacity of each bay required to support a tank load of the weight class of the bridge. Tank loads are placed at maximum eccentricity against one curb, increased 10 percent for impact, and moved along bridge to point of maximum effect for each bay.

7. Evaluation of Damage

a. BRIDGE. The two main girders of a bridge are independent of

Table 84. Shears and Bending Moments in Percentage of Maximum Capacity

	Span		30′		40′		50′			60′			70′				80′				90′				100′				110′				120′			
																																				
	Wt	Class	40		32		28			26			22				18				13				10											
SS	Shear	DL	12	4	16	8	19	12	4	23	16	8	27	19	12	4	31	23	16	8	35	27	19	12	4	39	31	23	16	8							
		LL	85	40	81	54	78	59	39	72	58	44	63	53	42	32	56	48	40	32	45	40	34	28	23	36	32	28	24	20							
		Total	97	44	97	62	97	71	43	95	74	52	90	72	54	36	87	71	56	40	80	67	53	40	27	75	63	51	40	28							
	Mom	DL	4	5	6	8	8	12	13	10	16	18	12	20	24	25	14	24	31	33	16	29	37	41	41	18	33	43	49	51							
		LL	37	42	38	50	38	56	59	36	57	65	32	54	65	66	30	51	64	68	25	45	57	64	65	21	37	49	56	58							
		Total	41	47	44	58	46	68	72	46	73	83	44	74	89	91	44	75	95	101	41	74	94	105	106	39	70	92	105	109							
	Wt	Class					80			67			64				51				44				31				23				18			
DS	Shear	DL	.....		.....		12	7	2	14	9	5	16	12	7	2	19	14	9	5	21	16	12	7	2	23	19	14	9	5	26	21	16	12	7	2	28	23	19	14	9	5
		LL	.....		.....		86	60	35	82	64	47	74	61	47	35	66	56	47	37	58	51	43	36	29	47	42	37	31	26	36	33	30	26	22	19	30	27	24	22	19	16
		Total	.....		.....		98	67	37	96	73	52	90	73	54	37	85	70	56	42	79	67	55	43	31	70	61	51	40	31	62	54	46	38	29	21	58	50	43	36	28	21
	Mom	DL	.....		.....		5	7	8	6	10	11	7	12	15	15	9	15	19	20	10	17	22	25	25	11	20	26	30	31	12	22	30	35	37	37	14	25	33	39	43	44
		LL	.....		.....		41	61	64	40	63	71	36	61	72	75	33	57	71	76	30	52	67	74	75	25	45	60	68	72	21	38	56	60	64	64	18	32	43	51	56	58
		Total	.....		.....		46	68	72	46	73	82	43	73	87	90	42	72	90	96	40	69	89	99	100	36	65	86	98	103	33	60	86	95	101	101	32	57	76	90	99	102
	Wt	Class															80				62				52				40				34			
TS	Shear	DL	.....		.....		.....			.....			.....				16	12	8	4	18	14	10	6	2	20	16	12	8	4	22	18	14	10	6	2	24	20	16	12	8	4
		LL	.....		.....		.....			.....			.....				68	58	47	36	55	48	40	33	26	51	45	40	34	27	43	39	34	30	26	21	35	31	28	25	22	19
		Total	.....		.....		.....			.....			.....				84	70	55	40	73	62	50	39	28	71	61	52	42	31	65	57	48	40	32	23	59	51	44	37	30	23
	Mom	DL	.....		.....		.....			.....			.....				7	13	16	17	8	15	19	21	21	9	17	22	25	26	10	19	25	29	31	32	12	21	28	34	36	37
		LL	.....		.....		.....			.....			.....				34	59	74	79	30	53	68	75	76	26	47	62	71	74	23	41	55	64	68	69	19	35	48	56	62	63
		Total	.....		.....		.....			.....			.....				41	72	90	96	38	68	87	96	97	35	64	84	96	100	33	60	80	93	99	101	31	56	76	90	98	100
																																									
	Wt	Class																								75					64						50					
DD	Shear	DL	.....		.....		.....			.....			.....				.....				.....					19	15	11	7	4	20	17	13	9	6	2	22	19	15	11	7	4
		LL	.....		.....		.....			.....			.....				.....				.....					59	52	45	38	31	52	46	41	36	31	25	43	39	35	31	27	23
		Total	.....		.....		.....			.....			.....				.....				.....					78	67	56	45	35	72	63	54	45	37	27	65	58	50	42	34	27
	Mom	DL	.....		.....		.....			.....			.....				.....				.....					8	14	19	21	22	9	16	21	25	27	27	10	18	24	29	31	32
		LL	.....		.....		.....			.....			.....				.....				.....					27	49	64	73	76	24	42	57	66	71	71	21	38	51	60	66	68
		Total	.....		.....		.....			.....			.....				.....				.....					35	63	83	94	98	33	58	78	91	98	98	31	56	75	89	97	100
	Wt	Class																													80						70					
TD	Shear	DL	.....		.....		.....			.....			.....				.....				.....					.....					20	16	12	9	5	2	21	18	14	11	7	4
		LL	.....		.....		.....			.....			.....				.....				.....					.....					49	44	38	33	28	23	43	39	35	31	27	23
		Total	.....		.....		.....			.....			.....				.....				.....					.....					69	60	50	42	33	25	64	57	49	42	34	27
	Mom	DL	.....		.....		.....			.....			.....				.....				.....					.....					8	15	20	23	25	25	9	17	22	27	29	30
		LL	.....		.....		.....			.....			.....				.....				.....					.....					22	40	53	62	66	67	19	35	47	56	61	63
		Total	.....		.....		.....			.....			.....				.....				.....					.....					30	55	73	85	91	92	28	52	69	83	90	93

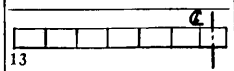
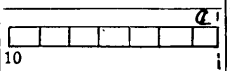
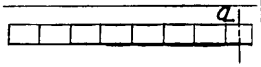
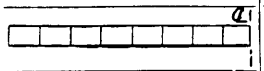
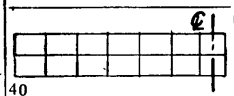
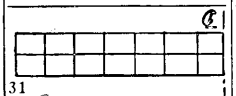
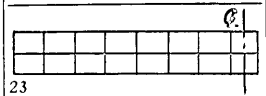
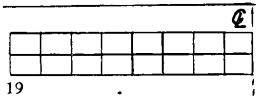
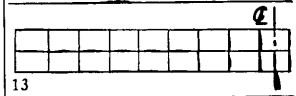
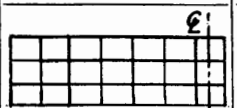
Span			130′							140′							150′							160′							170′						
																																					
DS	Wt	Class	13							10																											
	Shear	DL	30	26	21	16	12	7	2	33	28	23	19	14	9	5																					
		LL	25	22	19	17	15	13	11	21	19	16	14	12	11	10																					
		Total	55	48	40	33	27	20	13	54	47	39	33	26	20	15																					
	Mom	DL	15	27	37	44	49	52	52	16	30	41	49	56	59	60																					
		LL	14	25	34	41	46	48	48	11	20	28	34	38	41	42																					
		Total	29	52	71	85	95	100	100	27	50	69	83	94	100	102																					
TS	Wt	Class	23							18							13							10													
	Shear	DL	26	22	18	14	10	6	2	28	24	20	16	12	8	4	30	26	22	18	14	10	6	2	32	28	24	20	16	12	8	4					
		LL	30	25	22	20	18	16	14	25	22	19	17	15	13	12	20	18	16	13	12	11	9	8	17	15	13	12	10	9	8	7					
		Total	56	47	40	34	28	22	16	53	46	39	33	27	21	16	50	44	38	31	26	21	15	10	49	43	37	32	26	21	16	11					
	Mom	DL	13	23	31	38	42	44	44	14	25	35	42	47	50	51	15	27	38	46	52	57	59	59	16	29	41	50	58	63	66	67					
		LL	16	29	40	48	54	56	57	13	24	33	41	46	49	50	10	19	26	32	36	39	41	41	8	15	21	26	30	33	34	35					
		Total	29	52	71	86	96	100	101	27	49	68	83	93	99	101	25	46	64	78	88	96	100	100	24	44	62	76	88	96	100	102					
			130′							140′							150′							160′							170′						
																																					
DD	Wt	Class	40							31							23							19							13						
	Shear	DL	24	20	17	13	9	6	2	26	22	19	15	11	7	4	28	24	20	17	13	9	6	2	30	26	22	19	15	11	7	4	32	28	24	20	17	13	9	6	2
		LL	38	33	30	27	24	21	18	33	29	25	22	20	18	16	27	24	21	18	16	14	13	11	23	21	18	16	13	12	11	10	18	17	15	13	11	10	9	8	7
		Total	62	53	47	40	33	27	20	59	51	44	37	31	25	20	55	48	41	35	29	23	19	13	53	47	40	35	28	23	18	14	50	45	39	33	28	23	18	14	9
	Mom	DL	11	20	27	32	36	38	38	12	21	29	36	40	43	44	13	23	32	39	45	48	50	50	13	25	35	43	49	54	56	57	14	27	38	46	54	59	63	64	64
		LL	18	33	44	53	59	62	62	15	28	38	46	52	56	57	12	23	32	39	44	48	50	50	10	19	26	32	37	41	43	43	8	15	20	25	29	32	34	35	35
		Total	29	53	71	85	95	100	100	27	49	67	82	92	99	101	25	46	64	78	89	96	100	100	23	44	61	75	86	95	99	100	22	42	58	71	83	91	97	99	99
TD	Wt	Class	57							48							40							31							23						
	Shear	DL	23	20	16	12	9	5	2	25	21	18	14	11	7	4	27	23	20	16	12	9	5	2	28	25	21	18	14	11	7	4	30	27	23	20	16	12	9	5	2
		LL	38	34	31	28	25	21	18	36	31	27	25	22	20	17	32	28	25	21	19	17	15	13	28	25	22	19	16	15	13	12	25	23	21	18	16	14	12	11	10
		Total	61	54	47	40	34	26	20	61	52	45	39	33	27	21	59	51	45	37	31	26	20	15	56	50	43	37	30	26	20	16	55	50	44	38	32	26	21	16	12
	Mom	DL	10	18	25	30	33	35	35	11	20	27	33	37	40	41	12	22	30	36	41	45	46	47	12	23	32	40	46	50	52	53	13	25	35	43	50	55	58	60	60
		LL	17	31	43	51	57	60	60	15	28	39	47	53	56	57	13	25	34	42	47	51	53	53	11	21	30	36	42	46	48	49	9	17	24	30	35	38	41	42	42
		Total	27	49	68	81	90	95	95	26	48	66	80	90	96	98	25	47	64	78	88	96	99	100	23	44	62	76	88	96	100	102	22	42	59	73	85	93	99	102	102

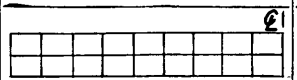
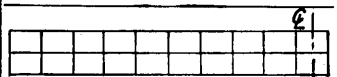
Table 84. Shears and Bending Moments in Percentage of Maximum Capacity—Continued.

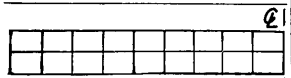
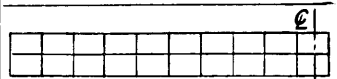


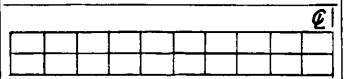
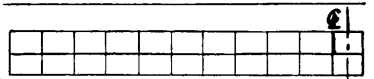
			130′							140′							150′							160′							170′						
DT	Wt	Class	80							67							65							56							50						
	Shear	DL	22	18	15	12	8	5	2	24	20	17	13	10	7	3	25	22	18	15	12	8	5	2	27	24	20	17	13	10	7	3	29	25	22	18	15	12	8	5	2
		LL	65	40	36	32	28	24	21	61	36	32	29	26	23	20	59	34	30	27	24	22	19	17	57	34	29	25	23	21	18	16	53	32	29	25	22	19	17	15	14
		Total	87	58	51	44	36	29	23	85	56	49	42	36	30	23	84	56	48	42	36	30	24	19	84	58	49	42	36	31	25	19	82	57	51	43	37	31	25	20	16
	Mom	DL	8	14	19	23	26	27	27	8	16	21	26	29	31	32	9	17	23	29	32	35	36	37	10	18	25	31	36	39	41	42	10	19	29	34	39	43	45	47	47
		LL	17	30	41	50	55	58	58	14	26	36	44	50	53	54	13	24	34	41	47	51	53	53	12	23	32	39	45	49	51	52	11	21	30	36	41	46	48	50	50
		Total	25	44	60	73	81	85	85	22	42	57	70	79	84	86	22	41	57	70	79	86	89	90	22	41	57	70	81	88	92	94	21	40	59	70	80	89	93	97	97

			80							70							
TT	Wt	Class															
	Shear	DL	26	23	20	16	13	10	7	3	28	25	21	18	15	12	8	5	2
		LL	59	35	30	27	25	22	20	18	55	33	29	25	22	20	18	16	14
		Total	85	58	50	43	38	32	27	21	83	58	50	43	37	32	26	21	16
	Mom	DL	9	17	24	30	34	37	39	39	10	18	26	32	37	41	43	44	44
		LL	13	24	33	41	47	51	54	55	11	21	29	36	41	46	48	50	50
		Total	22	41	57	71	81	88	93	94	21	39	54	68	78	87	91	94	94

Table 84. Shears and Bending Moments in Percentage of Maximum Capacity—Continued.

Span			180′									190′									
																					
DD	Wt	Class	10																		
	Shear	DL	33	30	26	22	19	15	11	7	4										
		LL	15	14	12	11	10	9	7	6	6										
		Total	48	44	38	33	29	24	18	13	10										
	Mom	DL	15	29	40	50	58	64	69	71	72										
		LL	6	12	17	21	24	26	28	29	30										
		Total	21	41	57	71	82	90	97	100	102										
TD	Wt	Class	18									12									
	Shear	DL	32	28	25	21	18	14	11	7	4	34	30	27	23	20	16	12	9	5	2
		LL	21	19	17	16	14	13	11	9	8	14	13	12	10	9	8	7	6	5	5
		Total	53	47	42	37	32	27	22	16	12	48	43	39	33	29	24	19	15	10	7
	Mom	DL	14	26	37	46	54	60	64	66	67	15	28	40	50	58	65	69	73	74	75
		LL	8	14	20	25	29	32	34	36	36	5	10	15	18	21	24	26	27	27	28
		Total	22	40	57	71	83	92	98	102	103	20	38	55	68	79	89	95	100	101	103

			180′									190′									
																					
DT	Wt	Class	40									31									
	Shear	DL	30	27	24	20	17	13	10	7	3	32	29	25	22	18	15	12	8	5	2
		LL	48	29	26	24	21	18	15	14	13	41	25	23	21	18	16	14	12	11	10
		Total	78	56	50	44	38	31	25	21	16	73	54	48	43	36	31	26	20	16	12
	Mom	DL	11	21	29	36	42	47	50	52	53	12	22	31	39	45	51	55	57	58	59
		LL	10	19	26	33	38	42	45	47	47	9	16	23	28	33	37	40	42	43	43
		Total	21	40	55	69	80	89	95	99	100	21	38	54	67	78	88	95	99	101	102
TT	Wt	Class	57									50									
	Shear	DL	30	26	23	20	16	13	10	7	3	31	28	25	21	18	15	12	8	5	2
		LL	50	30	27	24	21	18	16	15	13	44	27	25	22	20	17	15	13	12	11
		Total	80	56	50	44	37	31	26	22	16	75	55	50	43	38	32	27	21	17	13
	Mom	DL	10	20	28	34	40	44	47	49	50	11	21	30	37	43	48	52	54	55	55
		LL	9	18	25	31	36	40	43	44	45	8	16	23	28	33	37	39	41	42	42
		Total	19	38	53	65	76	84	90	93	95	19	37	53	65	76	85	91	95	97	97

Span			200′									210′									
																					
DT	Wt	Class	23									18									
	Shear	DL	50	30	27	24	20	17	13	10	7	3	53	32	29	25	22	18	15	12	8	5	2
		LL	33	20	19	17	15	14	12	11	9	8	27	17	15	14	13	12	11	9	8	7	6
		Total	83	50	46	41	35	31	25	21	16	11	80	49	44	39	35	30	26	21	16	12	8
	Mom	DL	12	23	33	42	49	55	59	62	64	65	13	25	35	44	52	58	64	68	70	71	72
		LL	7	13	19	23	27	31	33	35	36	36	6	11	15	19	22	25	28	29	30	31	31
		Total	19	36	52	65	76	86	92	97	100	101	19	36	50	63	74	83	92	97	100	102	103
TT	Wt	Class	40									29									
	Shear	DL	33	30	26	23	20	16	13	10	7	3	52	31	28	25	21	18	15	12	8	5	2
		LL	38	23	22	20	18	16	14	12	10	9	31	19	18	16	15	13	12	11	9	8	7
		Total	71	53	48	43	38	32	27	22	17	12	83	50	46	41	36	31	27	23	17	13	9
	Mom	DL	12	22	31	39	46	52	56	59	61	61	12	23	33	42	49	55	60	64	66	68	68
		LL	7	14	20	25	29	32	35	37	38	38	6	12	16	21	24	27	30	32	33	34	34
		Total	19	36	51	64	75	84	91	96	99	99	18	35	49	63	73	82	90	96	99	102	102

each other and each must be capable of taking at least half the total bridge loads. If one girder is damaged it cannot be assisted by any reserve capacity of the other.

b. GIRDER. (1) *Chords.* The members at a given section of a bridge which have an identical function and act together must be considered as a unit. For example, each main girder of a TD bridge consists of three trusses. If a chord of one truss is completely severed, the remaining undamaged construction of that girder is DD and capacity of the bridge is that of a DD bridge of the same span. Moreover, if the damaged truss is incapable of supporting itself, the DD capacity must be further reduced by half the weight in tons of the damaged truss. If the chord in one panel of SS bridge is completely severed, the capacity of the girder and bridge is reduced to zero.

(2) *Web members.* Effect of damage to diagonals and verticals depends partly on the condition of adjacent members as shown below.

(*a*) When both diagonals at a vertical section of a panel are seriously damaged, shear strength of the panel at that section is reduced to 30 percent because shear is resisted only by bending in the chords. Any damage to the chords or other diagonals in the same half of the panel reduces the shear strength to zero.

(*b*) When one of the diagonals at a vertical section is completely severed, panel shear strength at that section is reduced to 50 percent. Each diagonal takes half the shear, one in compression and the other in tension.

(*c*) Residual shear capacities of panels with damaged verticals in percent of undamaged capacity are shown in table 85.

Table 85. Residual shear capacity of panels with Severed Verticals in Percent of Undamaged Capacity

Location of damage	End verticals			Center verticals			End verticals at end posts		
	Upper half	Lower half	Both halves or through gusset	Upper half	Lower half	Both halves or through gusset	Upper half	Lower half	Both halves or through gusset
First story..	70	50*	30*	80	0	0	70	30	30
Second story	70	70	30	80	80	0	100	0	0
Third story.	70	70	30	80	80	0	100	100	100

* When both verticals at panel junction point are severed, these values are reduced to zero.

c. DEFORMED MEMBERS. When a member struck by flying metal is deformed and not severed, it must be watched as loads pass over the bridge. If further deformation takes place, it must be treated as if it were severed.

d. EXAMPLE. (1) *Given*: A 90-foot span, class 44 DS bridge damaged as follows:

(*a*) *Case 1.* In the third bay from one end, a flange of one channel in the bottom chord of one truss is missing.

(*b*) *Case 2.* In the second bay from the end, a flange of one diagonal channel is severed.

(*c*) *Case 3.* In the end bay, both values of the center vertical of one panel are completely severed.

(2) *Required.* What is the load class of the damaged bridge without repair reinforcement?

(3) *Solution.* (*a*) *Case 1.* From table 83, the residual strength of the damaged chord is 60 percent. As there are two trusses, the residual strength of the girder is—

$$\frac{100 + 60}{2} = 80 \text{ percent.}$$

From table 84, bending stresses in the third bay are—

$$\begin{aligned} \text{Dead load} &= 22 \\ \text{Live load} &= 67 \\ \text{Total} \quad & \overline{89} \text{ percent} \end{aligned}$$

The damaged girder section is capable of taking only 80 percent of its original capacity. Therefore, the rated bridge capacity must be lowered to reduce bending stresses at this section from 89 to 80 percent. Dead load remains the same. Therefore, live load must be reduced by 9 percent.

$$\text{Live load} = 67 - 9 = 58 \text{ percent.}$$

Reduction in live load is approximately proportional to the lowering of the load class.

$$\text{New load class} = 44 \times \frac{58}{67} = 38.1 \text{ or class } 38.$$

(*b*) *Case 2.* From table 82, residual strength of the diagonal with one flange severed is 25 percent. There are four diagonals resisting shear at each girder vertical cross section, three which have a residual strength of 100 percent each and one which has 25 percent. The total shear capacity of the damaged girder is therefore

$$\frac{325}{4} = 81 \text{ percent.}$$

From table 84, total shear in the second bay is 67 percent of maximum capacity, so this damage has no effect on the bridge class.

(*c*) *Case 3.* The center vertical of one panel being completely severed reduces shear capacity in that panel to 0 (table 85) with one truss carrying 0 percent shear and the other 100 percent shear. Therefore, the girder shear capacity is 50 percent.

From table 84, shear in the end bay is:

$$\begin{aligned} \text{Dead load} &= 21 \\ \text{Live load} &= 58 \\ \text{Total} \quad & \overline{79} \end{aligned}$$

Total load must therefore be reduced 29 percent to the girder shear capacity of 50 percent. With dead load remaining constant, allowable live load becomes 58 — 29 = 29 percent.

$$\text{Load class} = \frac{29 \times 44}{58} = 22$$

Load class of the bridge is therefore determined by this damage to a center vertical in an end bay and must be lowered to class 22.

c. EXAMPLE. (1) *Given*: The 90-foot, US class 44 DS bridge of example *d* above has the chord of one truss in the third bay from one end completely severed.

(2) *Required.* What is the load class of the damaged bridge without repair or reinforcement if—

(*a*) *Case 1.* The damaged truss is capable of supporting its own weight?

(*b*) *Case 2.* The damaged truss is not capable of supporting its own weight?

(3) *Solution.* (*a*) *Case 1.* From *b* above, capacity is reduced to that of a SS bridge of the same span or class 13.

(*b*) *Case 2.* From *b* above, capacity of the corresponding SS bridge must be further reduced by half the weight of the damaged truss. From table 1 the difference in weight of the two types of bridge bay is—

DS = 3.58 tons
SS = 2.93 tons
Diff = 0.65 tons

The damaged truss, therefore, weighs $9 \times 0.65 \times \frac{1}{2} = 2.93$ tons
Capacity of the 90-foot SS must be reduced by half this weight.

New weight class = 13 — 1.5 = 11.5 or class 11.

APPENDIX II

M1 FIXED BRIDGE

The M1 panel bridge is the same as the M2 panel bridge except that it is 23 inches narrower between curbs. The M1 bridge is limited standard and will be used only until existing stocks have been depleted. All of the foregoing material in this manual is applicable to the M1 bridge with the following exceptions:

1. Weight

Table 86 gives the weights of 10-foot M1 bridge bays.

Table 86. Weight of M1 Fixed Steel Panel Bridge in Tons Per Bay

Type of construction[1]	*Single transoms*	*Double transoms*
Bridge bays		
SS	2.52	2.96
DS	3.17	3.62
TS	3.78	4.24
DD	4.43	4.88
TD	5.65	6.10
DT[2]	6.13	6.58
TT[2]	7.96	8.42
Launching-nose bays		
SS	0.90	
DS	1.54	
DD	2.80	
Decking		
Chess and steel ribands	0.57	
Stringers only	0.66	
Miscellaneous		
Footwalks	0.17	
Overhead bracing (supports, transoms, sway bracing, and chord bolts)	0.45	

[1] Footwalks included. If four 3- by 12-inch planks are used on each side of bridge as wear treads, add 0.35 tons.

[2] Overhead bracing included.

2. Bridge Capacity

Table 87 gives safe and caution capacities of M1 panel bridge.

Table 87. Safe and Caution Capacities of M1 Panel Bridge

Span (ft.)	Construction													
	SS		DS		TS		DD		TD		DT		TT	
	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution	Safe	Caution
30	48	60												
40	40	51												
50	35	44	80	100										
60	30	38	70	89										
70	27	34	63	78	83	104								
80	22	28	53	66	73	91								
90	16	22	44	55	60	80	85	108						
100	11	14	38	48	53	66	74	93						
110			29	36	46	57	63	79	86	108				
120			23	30	38	48	53	67	74	92				
130			18	22	29	36	46	57	62	79				
140			13	17	23	29	38	48	52	66	86	108		
150			9	12	18	23	29	36	46	57	74	92		
160					13	18	23	31	35	44	63	79		
170					9	12	18	24	29	36	53	66	86	108
180							13	18	22	29	46	57	67	84
190							8	12	16	22	38	48	52	66
200									10	15	28	36	40	50
210											23	31	38	48

3. Strength of Parts

All M1 bridge parts have same strength as M2 parts except the M1 transom. Strength is given in table 88.

Table 88. Strength of M1 Transom

Part		Load	Strength (short tons)
Transom M1	Normal position.	Moment of resistance to bending.	46 ft-tons.
			35 ft-tons (reduced section)
		Maximum vertical shear.	19
	Lying on side.	Moment of resistance to bending.	7.5 ft-tons.
			5.0 ft-tons (reduced section).
		Maximum vertical shear.	28

4. Horizontal Clearance

The M1 panel bridge is 127 inches wide between steel ribands and 148 inches between trusses (fig. 336).

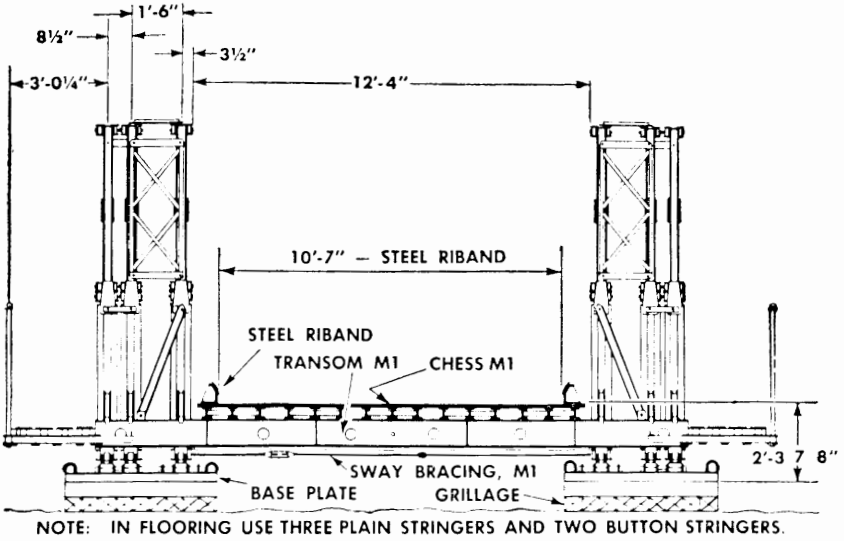


Figure 336. Triple-double M1 panel bridge showing critical horizontal clearance.

5. Description of Equipment

The equipment used in the M1 panel bridge is the same as in the M2 bridge except for the difference shown in table 89. Figures 337 through 343 illustrate the M1 parts which are used in place of M2 parts. The $7\frac{5}{16}$-inch bearing and $7\frac{3}{16}$-inch jack shoe are normally used without base

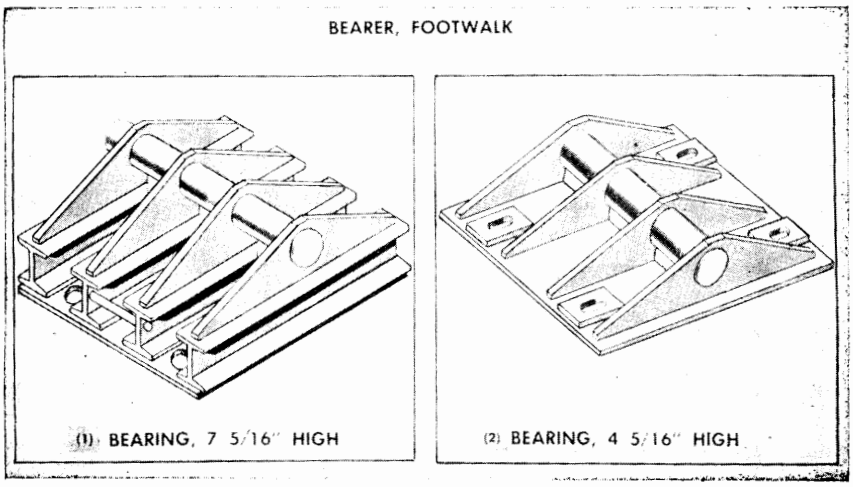


Figure 337. Bearings.

Table 89. Differences of Equipment in M1 and M2 Panel Bridges

Item	M1 bridge			M2 bridge			Figure reference
	Average unit weight (lb)	Main dimension	No. in one set[1]	Average unit weight (lb)	Main dimension	No. in one set	
Bridge Parts							
Bearing, 4 5/16" high	68	4 5/16" high.	16[2]	68	4 5/16" high	16	337
Bearing, 7 5/16" high	101	7 5/16" high.	16[2]	..	..	..	337
Brace, sway, M1	63.5	15'11⅛" long (closed)	64	..	..	..	338
Brace, sway, M2	..	..	..	68	16'9⅛" long (closed)	64	338
Chess, M1	52.2	11'11" long	336	..	..	..	339
Chess, M2	..	..	..	65	13'10" long	336	339
Chess, junction, M1	86	3'11¾" long	..[3]	..	..	..[3]	340
Chess, junction, M2	..	..	..[3]	149	6'10½" long	..[3]	340
Pedestal, ramp, M1	91	10⅜" high opening	16	..	..	..	341
Pedestal, ramp, M2	..	..	..	93	11" high opening	16	341
Ramp, plain	338	9'11⅝" long	24	338	9'11⅝" long	32	8
Stringer, plain	260	9'11⅝" long	48	260	9'11⅝" long	64	8
Transom, M1	433.3	18" long; no cover plates; 5 stringer lugs	56	..	..	..	342
Transom, M2	..	..	..	618	19'11" long; cover plates; 6 stringer lugs	56	342
Erection Equipment							
Shoe, jack, 4 3/16" high	36	4 3/16" high	8[2]	36	4 3/16" high	8	343
Shoe, jack, 7 3/16" high	68	7 3/16" high	8[2]	..	..	..	343

[1] M1 bridge set is same as M2 bridge set except for differences shown in this table. See table 10 for list of equipment supplied in one set of M2 panel bridge. One bridge set contains equipment to erect two 80-foot double-single bridges with launching nose or one 130-foot double-double bridge with launching nose.

[2] Only 16 bearings and 8 jack shoes of one type are issued with one M1 bridge set. Bearings 4 5/16 inches high and jack shoes 4 3/16 inches high are issued only when base plates are issued with the bridge set. Base plates are isued with M1 bridge set when available.

[3] Junction chess are not issued in bridge set. They are procured separately.

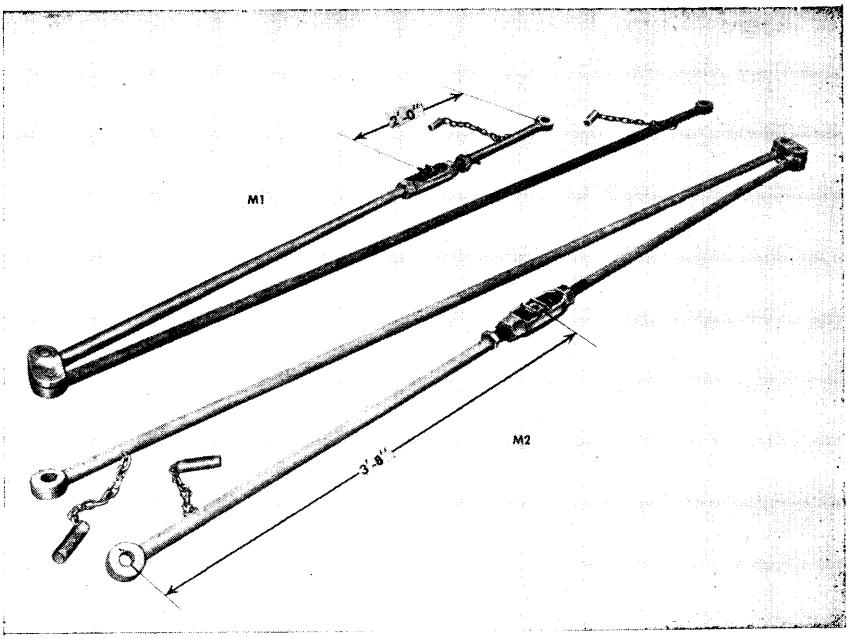


Figure 338. Sway braces for M1 and M2 bridges.

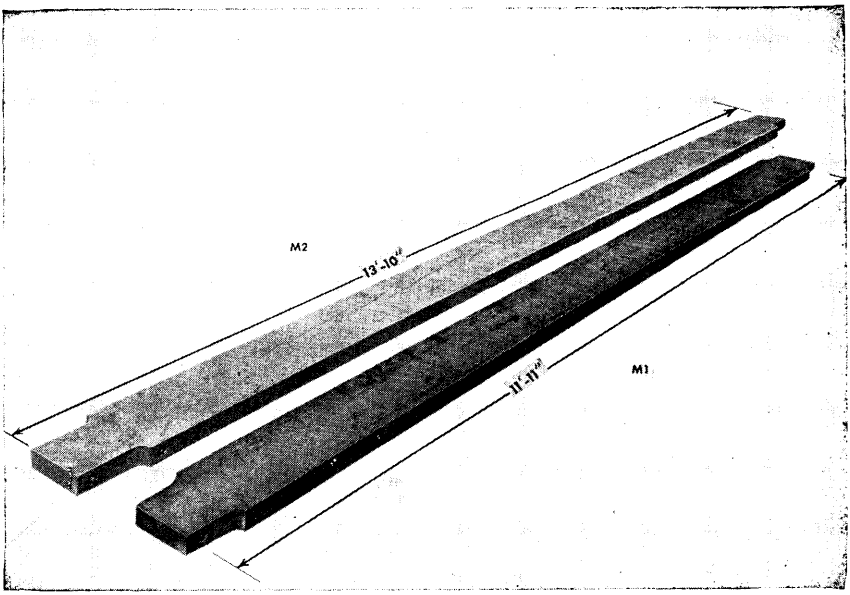


Figure 339. Chess for M1 and M2 bridges.

plates. If base plates are used, timbers must be set in the depression of the base plate to provide a flat surface for the jack shoe as illustrated in figure 344.

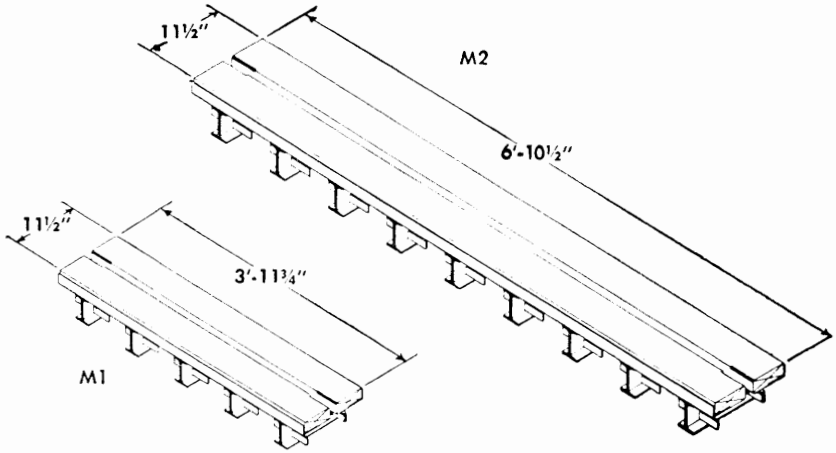


Figure 340. Junction chess for M1 and M2 bridges.

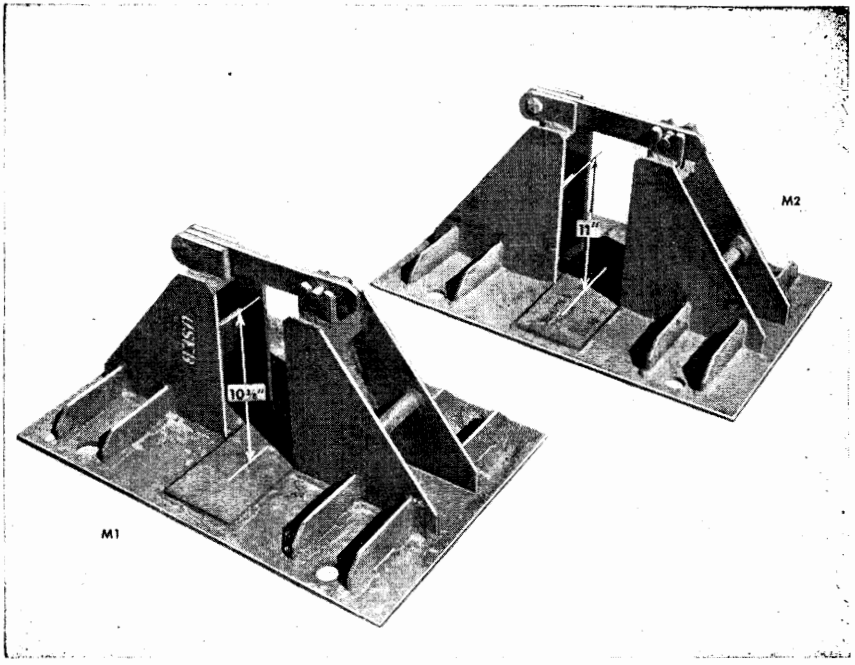


Figure 341. Ramp pedestals for M1 and M2 bridges.

6. Lay-out of Site and Equipment

Lay-out of M1 bridge is same as for M2 bridge except for narrower lateral spacing of rollers and base plates.

a. Rocking Rollers. Rocking rollers and templates for M1 bridge are spaced laterally as shown in figure 345. A stringer is used as a distance gage as shown in figure 347.

Table 91. Maximum base plate and launching-roller reactions in tons at One Corner of M1 Bridge

SS	Span in feet	30	40	50	60	70	80	90	100			
	Safe capacity	48	40	35	30	27	22	16	11			
	Caution capacity	60	51	44	38	34	28	22	14			
	Base-plate reaction[1]	33	29	26	24	22	18	18	14			
	Launching-roller reaction[2]	5.4	6.4	7.7	9.2	11.0	12.2	13.7	12.6			
DS	Span in feet	50	60	70	80	90	100	110	120	130	140	150
	Safe capacity	80	70	63	53	44	38	29	23	18	13	9
	Caution capacity	100	89	78	66	55	48	36	30	22	17	12
	Base-plate reaction[1]	56	51	46	41	36	32	28	39	22	21	19
	Launching-roller reaction[2]	10.3	12.6	14.3	16.6	16.8	18.3	20.3	22.0	23.6	21.4	20.2
TS	Span in feet	70	80	90	100	110	120	130	140	150	160	170
	Safe capacity	83	73	64	53	46	38	29	23	18	13	9
	Caution capacity	104	91	80	66	57	48	36	29	23	18	12
	Base-plate reaction[1]	60	55	51	45	40	36	31	29	27	26	24
	Launching-roller reaction[2]	16.3	18.8	21.3	23.6	23.6	25.3	27.6	29.8	28.1	27.2	28.3
DD	Span in feet	90	100	110	120	130	140	150	160	170	180	190
	Safe capacity	85	74	63	53	46	38	29	23	18	13	8
	Caution capacity	108	93	79	67	57	48	36	31	24	18	12
	Base-plate reaction[1]	66	60	54	49	44	40	36	35	33	32	29
	Launching-roller reaction[2]	23.8	25.6	29.6	31.8	31.8	34.9	37.6	35.4	37.8	35.6	38.0
TD	Span in feet	110	120	130	140	150	160	170	180	190	200	
	Safe capacity	86	74	63	52	46	35	29	22	16	10	
	Caution capacity	108	92	79	66	57	44	36	29	22	15	
	Base-plate reaction[1]	72	65	60	56	50	47	45	43	41	39	
	Launching-roller reaction[2]	35.8	39.2	43.3	46.4	46.8	47.8	46.6	45.0	44.0	47.0	

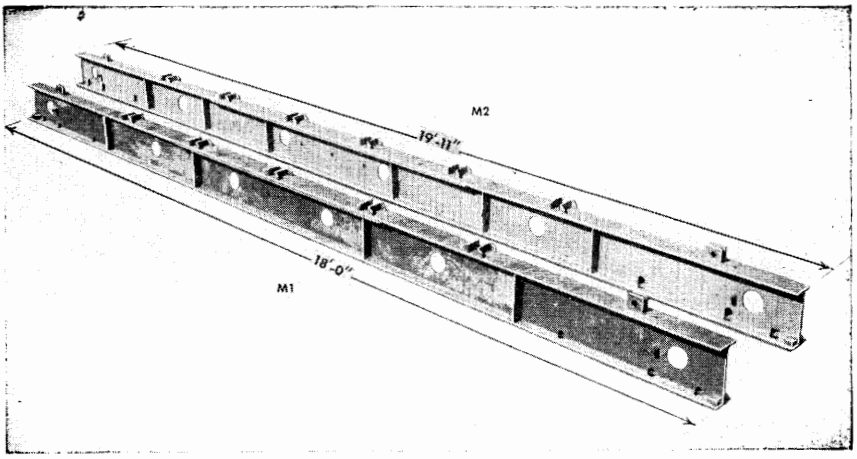


Figure 342. Transoms for M1 and M2 bridges.

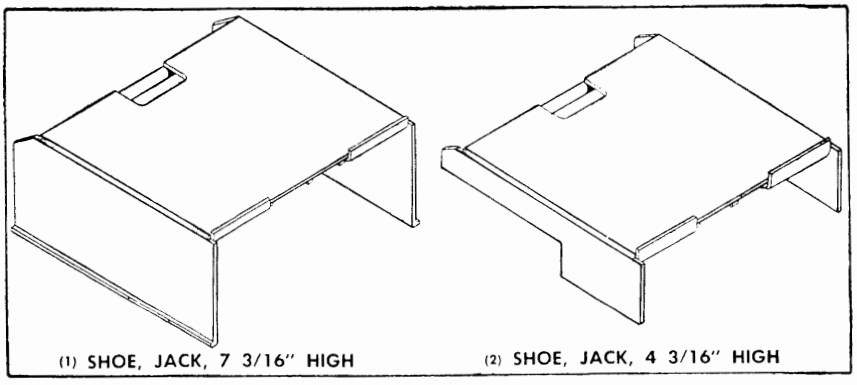


Figure 343. Jack shoes.

b. PLAIN ROLLERS. Plain rollers and templates for M1 bridge are spaced laterally as shown in figure 346. When one pair of rollers is used, a stringer is used as a distance gage as shown for rocking rollers.

c. BASE PLATES. Base plates for M1 bridge are spaced laterally as shown in figure 347.

7. End Supports

The grillages described in chapter 11 are used with the M1 bridge. Table 90 gives the types of grillage needed for various spans of M1 bridge. Table 91 gives the load on the grillage at one corner of the M1 bridge.

8. Construction

M1 panel bridge is constructed and launched the same as the M2 bridge except that only five stringers or ramps are used in each bay, and double transoms are used for loads of 50 tons and over.

DT	Span in feet	140	150	160	170	180	190	200	210			
	Safe capacity	86	74	63	53	46	38	28	23			
	Caution capacity	108	92	79	66	57	48	36	31			
	Base-plate reaction[1]	78	72	69	66	61	59	54	53			
	Launching-roller reaction[2]	49.8	53.8	57.8	59.2	55.2	44.7	52.3	53.0			
TT	Span in feet	170	180	190	200	210						
	Safe capacity	86	67	52	40	38						
	Caution capacity	108	84	66	50	48						
	Base-plate reaction[1]	97	88	81	73	73						
	Launching-roller reaction[2]	60.0	60.0	60.0	60.0	60.0						

[1] Includes weight of footwalks, ramps, bearings, and base plate. Live load assumed to be caution load on center line of bridge.
[2] Includes weight of rocking rollers, bearings, and template. Bridge launched without footwalks.

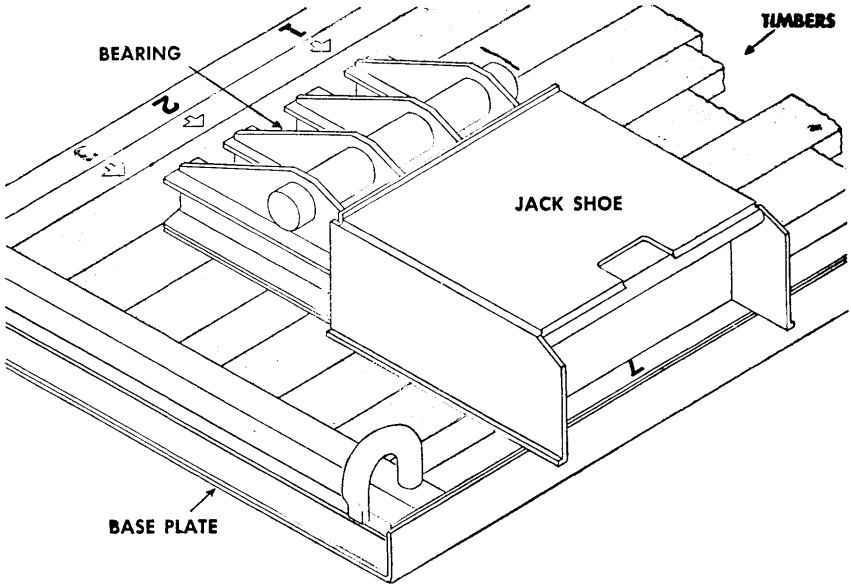


Figure 341. High jack shoe and bearing on base plate. Timbers are set in depression of base plate to provide a flat surface for the jack shoe.

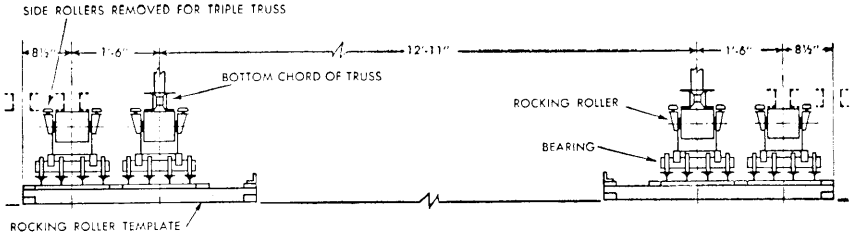
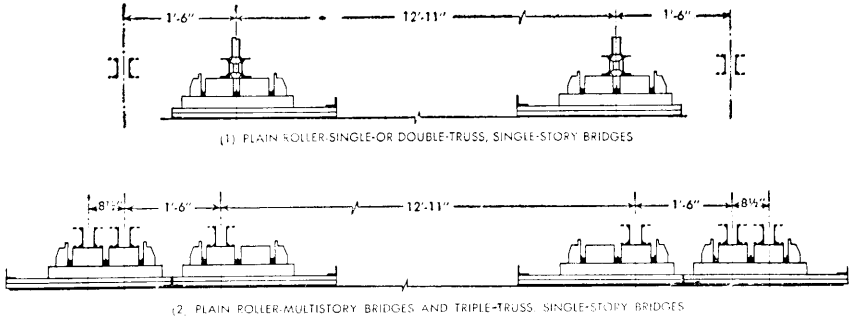


Figure 345. Lateral spacing of rocking-roller templates for M1 bridge.



(1) Plain rollers—Single- or double-truss, single-story bridges.
(2) Plain rollers—multistory bridges and triple-truss single-story bridges

Figure 346. Lateral spacing of plain-roller templates.

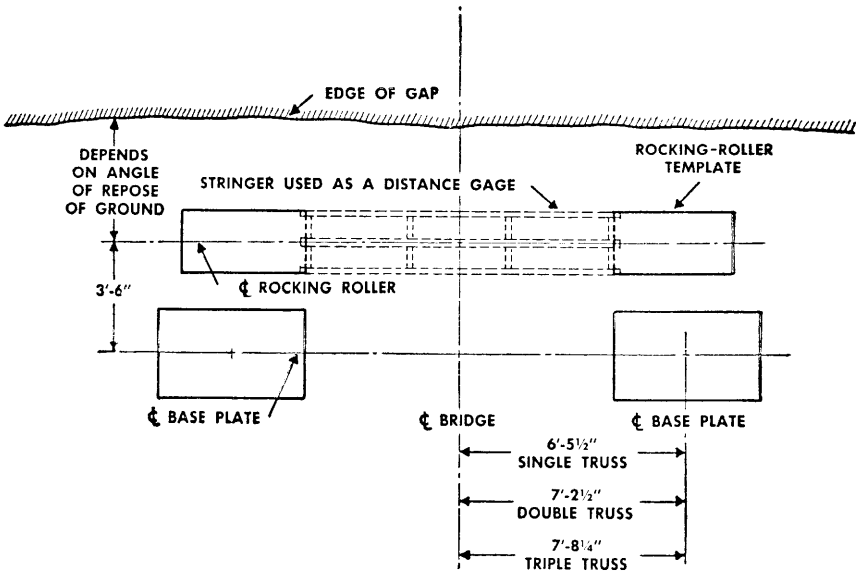


Figure 347. Lateral spacing of base plates in M1 bridge.

9. Two-Lane Through Type Bridge

Two-lane M1 panel bridge is constructed and launched the same as the two-lane M2 bridge. However, since the use of double transoms is undesirable the capacity of the two-lane M1 bridge is limited to 50 tons.

10. Deck Type Bridge

Figure 348 illustrates the use of M1 panel bridge deck on a two-lane deck type panel bridge.

11. Spans Without End Posts

Table 92 lists the maximum spans of M1 bridge that can be built without end posts or additional panels.

Table 92. Limiting Spans for M1 Bridges Without End Posts or Additional Panels[1]

US Bridge class (tons)	Type of construction		
	SS	DS	TS
	Maximum allowable span (feet)		
20	50	120[2]	140[2]
30	20	100[2]	120[2]
35	20	90	120[2]
45	. .	50	100[2]
65	. .	30	50

[1] Maximum allowable end shear for bridge without end posts is 14 tons per truss. An allowance of 30 percent of live load is made for impact and eccentricity of load. Limits are based on the effect of tracked vehicles.

[2] Moment governs. Limits are same as for bridge *with* end posts.

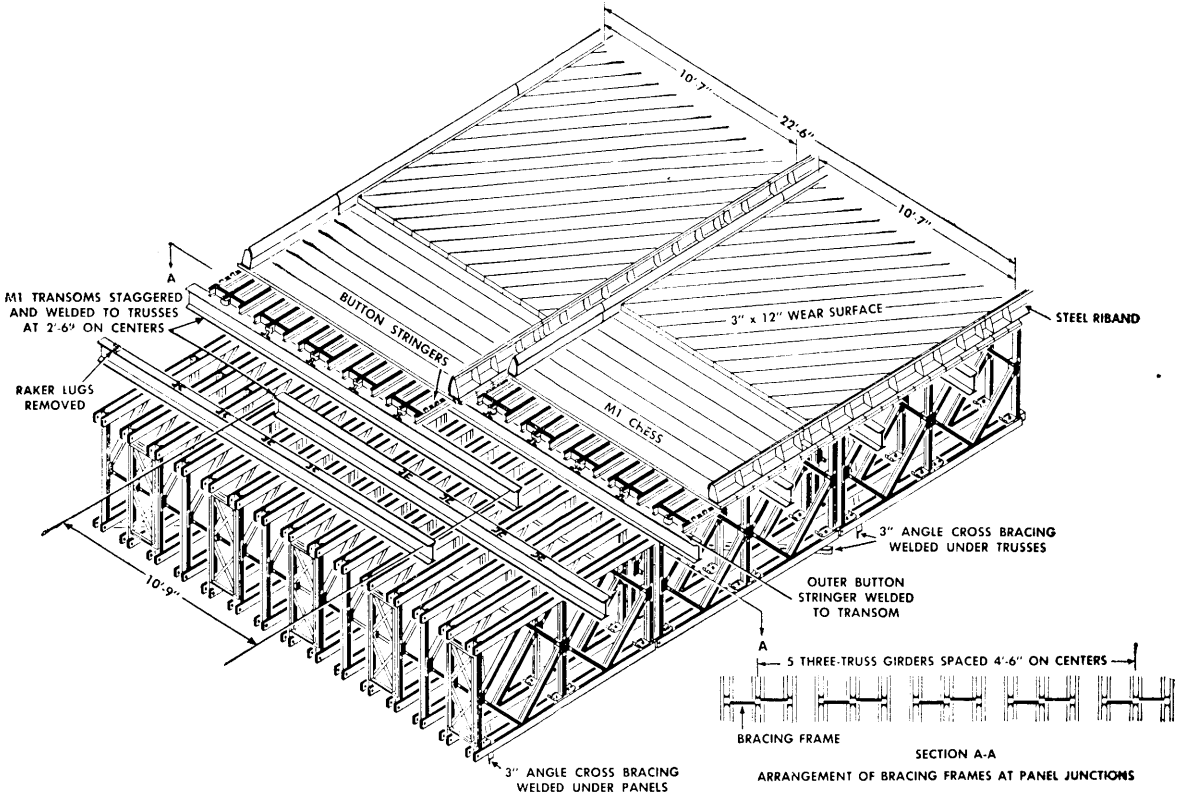


Figure 348. Details of standard M1 panel bridge deck on a two-lane deck type panel bridge.

APPENDIX III

BRITISH BRIDGES

1. Bailey Pontoon Bridge and Rafts

a. BRIDGE. The Bailey pontoon bridge consists of a series of short Bailey spans supported on floating pontoon piers with approach spans from each bank. The spans are joined together by special parts (fig. 349). The three main parts of the bridge are the floating bays, end floating bays, and landing bays. Bridges of various capacities can be constructed by varying the type and length of bays. A typical class 40 (British) bridge consists of 40-foot single-single floating bays and end bays, and 130-foot double-double landing bays.

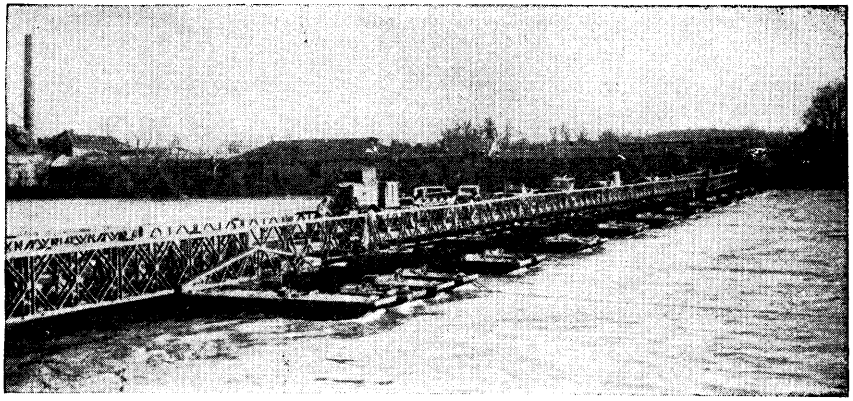


Figure 349. Bailey pontoon bridge with SS floating bays and TS landing bays.

b. RAFTS. Rafts are constructed with Bailey superstructure on pontoons. A typical class 40 (British) raft consists of four pontoons and 60 feet of single-single superstructure (fig. 350).

2. Bailey Deck Bridge

The deck bridge was primarily designed to carry loads of class 70 to 100 (British). It is always of quadruple-truss construction and may be single, double, or triple depth. The bridge is supported at its top chord level by special hornbeams and posts attached to end bays. To prevent laborious jacking down, launching is accomplished by use of a launching nose above top chord and a tail with special launching slides. These slides

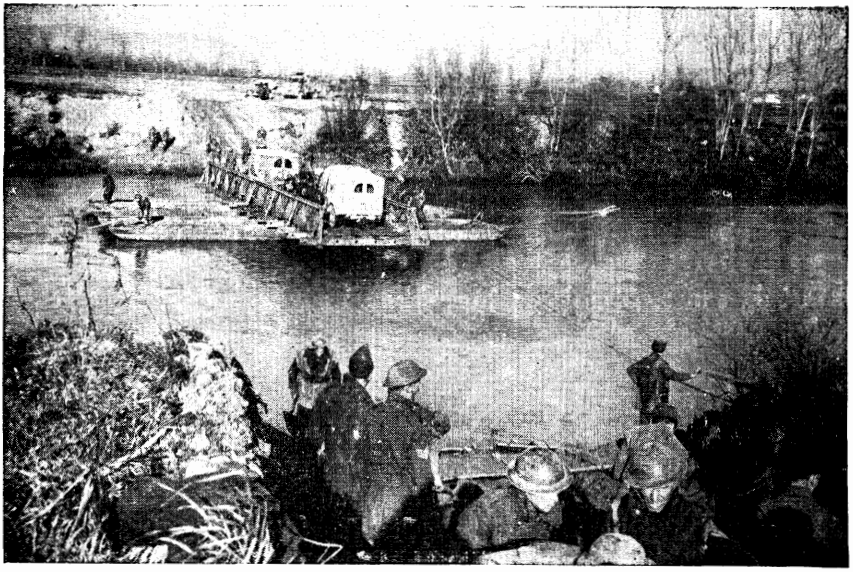


Figure 350. Typical class 40 raft.

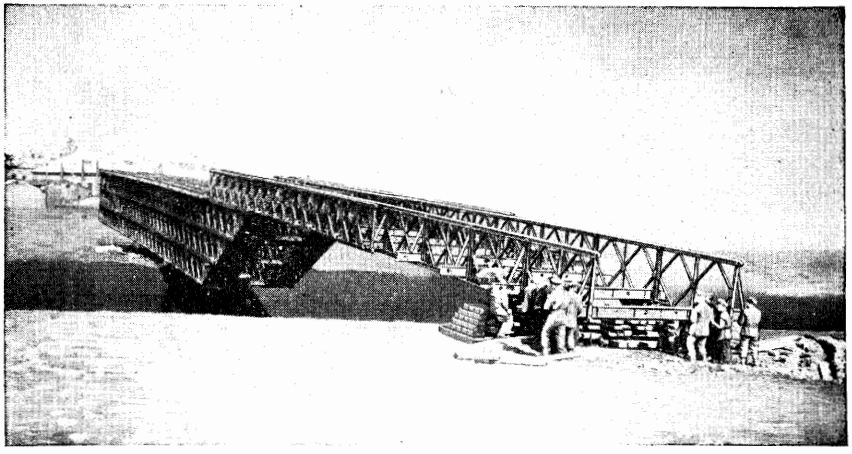


Figure 351. Launching Bailey deck bridge.

allow the entire bridge and its tail to be rolled out as one unit and, when the tail is unclamped, they permit the end of bridge to slide down the sloping face of the tail while the tail itself is pushed out backward by the weight of the bridge (figs. 351 and 352).

3. Bailey Mobile Bridge

The class 40 (British) bridge consists of a 70-foot span and an 80-foot span of double-single bridge hinged together, the former forming an

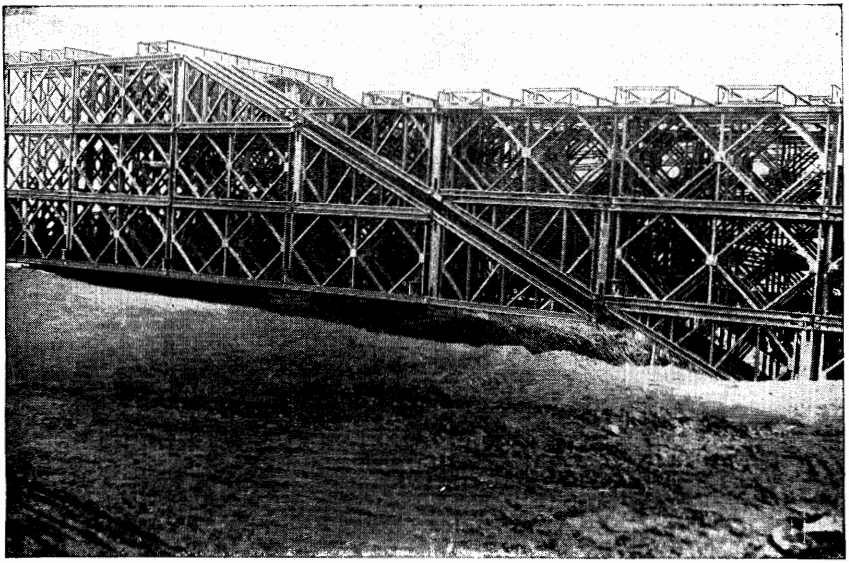


Figure 352. Bailey deck bridge tail with special launching slides.

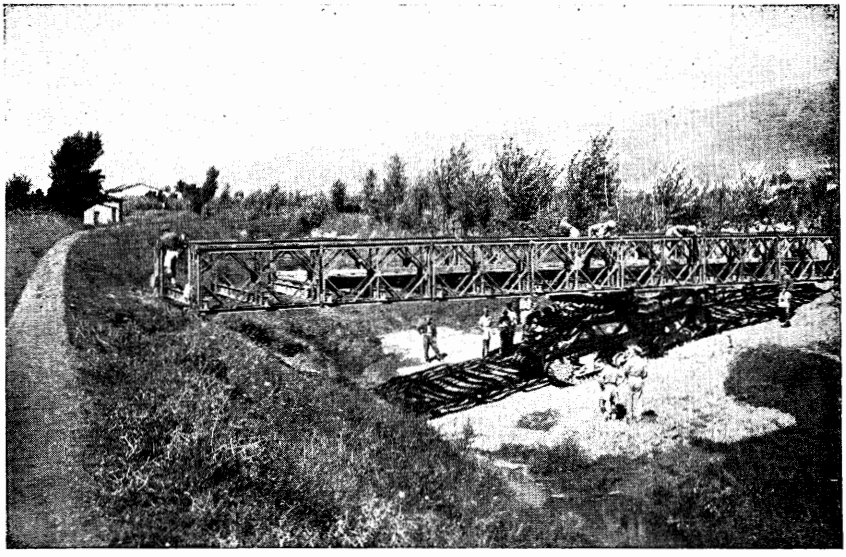


Figure 353. Expedient mobile bridge.

approach span and the latter the gap span. The combined bridge is supported at its center on caterpillar tracks and provided with a pusher bar at the rear for connection to a tank. Hand-operated hydraulic mechanism at the hinge elevates the nose of the bridge for moving forward and launching. Figure 353 shows an expedient version of the mobile bridge consisting of an 80-foot double-single bridge mounted on a Sherman tank.

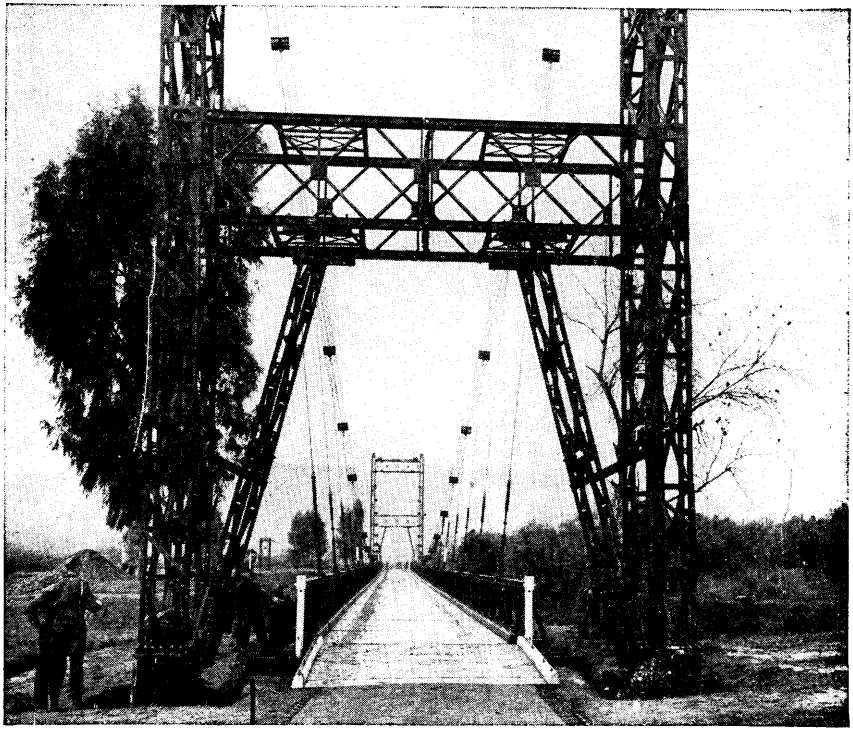


Figure 354. Bailey suspension bridge.

4. Bailey Suspension Bridge No. 2

In the Bailey suspension bridge No. 2, standard Bailey bridge equipment, supplemented by special parts and tools, is used. In addition, certain "common user" items are required. A clear span of 400 feet is provided, on which up to five vehicles of class 12 (British) may be placed simultaneously. The vehicles must be spaced 80 feet head to tail. Class 18 (British) loads can also be carried singly on this span. Figure 354 shows a suspension bridge.

APPENDIX IV

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APPENDIX V

BRIDGE CARD DATA

NUMBER OF PARTS REQUIRED FOR BRIDGE AND NOSE

ITEM	UNIT WEIGHT (lb)	SPARES INCLUDED	TRUSS CONSTRUCTION: SINGLE-SINGLE	DOUBLE-SINGLE				TRIPLE-SINGLE			
			CAPACITY (tons)								
			40	32	80	67	64	51	44	80	62	52	40
			SPAN (ft)										
			30	40	50	60	70	80	90	80	90	100	110
Bearer, footwalk	23	2 or 4	16	20	24	28	32	36	40	32	40	46	50
Bearing	68		4	4	8	8	8	8	8	8	8	8	8
Belt, bracing	1	25%	20 / 10	25 / 15	30 / 15	35 / 20	40 / 20	45 / 25	50 / 30	45 / 25	50 / 30	55 / 30	60 / 35
Bolt, chord	7.5	10%	—	—	—	—	—	—	—	—	—	—	—
Bolt, riband, guardrail, "J"	4.5	10%	62	70	79	88	97	106	114	106	114	123	132
Brace, sway, M2	68	10% to 4 max	2 / 2	9 / 4	11 / 4	13 / 7	15 / 7	18 / 9	20 / 11	18 / 9	20 / 11	22 / 11	24 / 13
Chess, M2	65	10% to 20 max	100	114	129	143	157	172	186	172	186	200	215
Clamp, transom	T	10% to 20 max	13 / 4	20 / 7	26 / 7	33 / 9	39 / 9	45 / 11	51 / 13	45 / 11	51 / 13	58 / 13	64 / 15
Footwalk	104	2	8	10	12	14	16	18	20	18	20	22	24
Frame, bracing	44	10%	7 / —	11 / —	13 / —	15 / —	18 / —	20 / —	18 / —	20 / —	22 / —	24 / —	—
Panel	577	10% to 10 max	7 / 4	9 / 7	22 / 7	26 / 9	31 / 9	35 / 11	40 / 13	53 / 11	59 / 13	66 / 13	72 / 15
Pedestal, ramp, M2	93	—	8	8	8	8	8	8	8	8	8	8	8
Pin, panel	6.1	20% to 50 max	19 / 8	24 / 10	58 / 10	67 / 14	77 / 14	86 / 16	96 / 24	110 / 16	125 / 19	139 / 24	154 / 29
Pin, panel, short	5.8	—	—	—	—	—	—	—	16	16	16	—	—
Pin, safety	0.13	25% to 70 max	20 / 6	25 / 10	60 / 10	70 / 15	80 / 15	90 / 20	100 / 22	135 / 20	150 / 25	165 / 25	180 / 30
Plate, base	381	—	4	4	4	4	4	4	4	4	4	4	4
Plate, tie	35.3	10%	—	—	—	—	—	—	20	22	24	26	—
Post, end, female	120	2	4	4	6	6	6	6	6	8	8	8	8
Post, end, male	121	2	4	4	6	6	6	6	8	8	8	8	8
Post, footwalk	10	10% to 4 max	15	20	24	29	33	37	42	37	42	46	50
Raker	22	10%	9 / 4	11 / 7	13 / 7	15 / 9	18 / 9	20 / 11	22 / 13	20 / 11	22 / 13	24 / 13	26 / 15
Ramp, button	348	—	8	8	8	8	8	8	8	8	8	8	8
Ramp, plain	338	—	16	16	16	16	16	16	16	16	16	16	16
Riband, guardrail, steel	215	—	14	16	18	20	22	24	26	24	26	28	30
Rope, handrail, ⅝" x 150'	20	—	2	2	2	2	2	2	2	2	2	2	2
Stringer, button	267	10%	7	9	11	13	15	18	20	18	20	22	24
Stringer, plain	260	10% to 4 max	13	18	22	26	31	35	40	35	40	44	48
Support, overhead bracing	150	10% to 4 max	—	—	—	—	—	—	—	—	—	—	—
Transoms, M2 [1]	618	10% to 4 max	9 / 2	11 / 3	13 / 3	15 / 4	18 / 4	20 / 6	22 / 7	20 / 6	22 / 7	24 / 7	26 / 8

ITEM	TRUSS CONSTRUCTION: DOUBLE-DOUBLE				TRIPLE-DOUBLE					DOUBLE-TRIPLE					TRIPLE-TRIPLE				
	CAPACITY (tons)																		
	73	64	50	40	80	70	57	48	40	80	67	63	56	50	40	80	70	57	50	40
	SPAN (ft)																			
	100	110	120	130	110	120	130	140	150	130	140	150	160	170	180	160	170	180	190	200
Bearer, footwalk	46	50	54	58	50	54	58	62	66	58	62	66	70	74	78	70	74	78	82	86
Bearing	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Belt, bracing	265 / 30	290 / 35	315 / 35	340 / 40	400 / 30	435 / 35	470 / 60	505 / 70	540 / 65	480 / 70	515 / 70	550 / 85	585 / 100	620 / 100	655 / 100	820 / 175	870 / 190	920 / 230	970 / 245	1020 / 295
Bolt, chord	88	97	106	114	145	158	172	185	198	286	308	330	352	374	396	493	524	554 / 18	585 / 18	616 / 35
Bolt, riband, guardrail, "J"	123	132	141	150	132	141	150	158	167	150	158	167	176	185	194	176	185	194	202	211
Brace, sway, M2	22 / 11	24 / 13	26 / 13	28 / 13	24 / 11	26 / 13	28 / 15	30 / 15	32 / 18	34 / 15	36 / 15	38 / 15	40 / 18	42 / 20	44 / 20	64 / 31	70 / 33	74 / 37	78 / 40	82 / 44
Chess, M2	200	215	228	241	215	228	241	254	267	241	254	267	280	293	306	280	293	306	319	332
Clamp, transom	99 / 15	99 / 15	108 / 15	117 / 18	117 / 13	161 / 15	174 / 22	187 / 24	200 / 29	117 / 24	125 / 21	134 / 29	143 / 33	152 / 33	161 / 33	213 / 53	226 / 59	239 / 66	252 / 70	262 / 79
Footwalk	22	24	26	28	24	26	28	30	32	28	30	32	34	36	38	34	36	38	40	42
Frame, bracing	46 / —	51 / —	55 / —	59 / —	51 / —	55 / —	59 / 4	64 / 7	68 / 9	90 / 7	97 / 7	103 / 9	110 / 11	117 / 11	123 / 11	110 / 22	117 / 24	123 / 31	130 / 33	136 / 42
Panel	88 / 15	97 / 15	106 / 15	114 / 18	142 / 13	154 / 15	166 / 22	178 / 24	190 / 29	166 / 24	178 / 24	190 / 29	202 / 33	214 / 33	226 / 33	298 / 59	316 / 59	334 / 75	352 / 79	370 / 97
Pedestal, ramp, M2	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Pin, panel	202 / 24	221 / 29	240 / 29	259 / 34	302 / 24	326 / 29	350 / 34	374 / 38	398 / 48	362 / 38	386 / 38	410 / 48	434 / 48	458 / 58	482 / 58	602 / 96	638 / 106	674 / 120	710 / 130	746 / 168
Pin, panel, short	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pin, safety	210 / 25	230 / 30	250 / 30	270 / 35	343 / 25	370 / 30	394 / 35	418 / 40	442 / 50	382 / 40	406 / 40	430 / 50	454 / 60	478 / 60	502 / 60	646 / 100	682 / 110	718 / 125	754 / 135	790 / 175
Plate, base	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Plate, tie	—	—	—	—	48	53	57	62	66	—	—	—	—	—	—	103	110	117	123	130
Post, end, female	6	6	6	6	8	8	8	8	8	6	6	6	6	6	6	8	8	8	8	8
Post, end, male	6	6	6	6	8	8	8	8	8	6	6	6	6	6	6	8	8	8	8	8
Post, footwalk	46	50	54	58	50	54	58	62	66	58	62	66	70	74	78	70	74	78	82	86
Raker	24 / 11	26 / 13	29 / 13	31 / 15	26 / 13	29 / 15	31 / 18	33 / 18	35 / 20	31 / 18	33 / 20	35 / 22	37 / 22	40 / 22	42 / 22	33 / 35	35 / 40	37 / 40	40 / 42	42 / 46
Ramp, button	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Ramp, plain	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Riband, guardrail, steel	32	34	36	38	34	36	38	40	42	44	46	48	50	52	54	48	50	52	54	56
Rope, handrail, ⅝" x 150'	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4	4
Stringer, button	22	24	26	29	24	26	29	31	33	29	31	33	35	37	40	35	37	40	42	44
Stringer, plain	44	48	52	56	48	52	56	60	64	56	60	64	68	72	76	68	72	76	80	84
Support, overhead bracing	—	—	—	—	—	—	—	—	—	29	31	33	35	37	40	35	37	40	42	44
Transoms, M2 [1]	21 / 7	24 / 8	26 / 8	29 / 9	26 / 7	29 / 8	31 / 9	33 / 9	35 / 10	45 / 9	48 / 9	51 / 10	54 / 11	57 / 11	60 / 11	34 / 17	37 / 18	40 / 20	43 / 21	46 / 23

TRUCK No.	TRUCK LOAD	LOAD WEIGHT (lb)	NO OF LOADS IN ONE BRIDGE TRANSPORT COMPANY	NUMBER OF LOADS REQUIRED PER BRIDGE										NUMBER OF LOADS REQUIRED PER BRIDGE										
1	Accessory load	6024	2	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
2	Ramp load	4939	8	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	Decking load	6845	8	2	2	3	3	4	5	5	5	5	6	6	6	7	6	6	7	5	5	6	8	9	10	10
4	Panel load	5791	16	2	2	3	4	5	5	6	7	8	9	10	11	12	13	14	17	19	21	22	24	21	22	24
5	Transom load	5336	8	2	2	2	3	3	3	4	3	4	4	4	4	4	5	5	4	5	5	6	7	7	8	8
6	Footwalk load	3058	2	1	1	1	1	1	1	2	1	2	2	2	2	2	2	2	2	2	2	3	3	2	3	3
7	Grillage load [2]	5796	2	1	1	—	—	1	1	1	—	—	1	1	—	—	—	2	—	—	—	—	—	—	—	—
7A	Supplementary grillage load [3]	5988	—	—	—	3	2	—	—	—	3	2	—	—	—	3	3	2	—	.3	3	3	3	—	3	3
8	Overhead-bracing load	5700	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	Crib-pier load	6064	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[1] Two nose transoms are used for ramps.

[2] Grillages satisfactory for soil with safe bearing pressure of 2 tons per square foot.

[3] Grillages supplied will not support these bridges, and must be improvised in the field.

NUMBER OF PARTS IN STANDARD TRUCK LOADS

TRUCK LOAD #1 - ACCESSORY LOAD

7	Bag, transport
8	Bar, carrying
1	Chest, delineation equipment, w/2 box, sign 100 marker luminous
2	Extractor, pin
6	Holdfast, w/8 pickets
3	Jack, chord
5	Jack, ratchet-lever, 15-ton
6	Lever, panel
6	Link, launching-nose, Mk II
150 lb	Nail, 40d
6	Roller, plain
6	Roller, rocking
4	Shoe, jack
6	Sledge, blacksmith
5 lb	Spike, 3/8"x8"
1	Tackle, heavy consisting of: 2 block, triple, for 1" rope 1 rope, sisal, 1"x600' 2 shackle, anchor, 1" 2 sling, wire-rope, 5/8"x8', w/eye at one end & hook at other
1	Tackle, light, consisting of: 2 block, snatch, for 3/4" rope 4 block, double, for 3/4" rope 4 rope, lashing, 5/8"x25' 1 rope, sisal, 3/4"x600'
6	Template, plain-roller
4	Template, rocking-roller
8	Wedge, hardwood, (pr)
8	Wrench, ratchet, w/1-1/8" & 1-7/8" sockets

TRUCK LOAD #2 - RAMP LOAD

7	Bag, transport
2	Bearing
3	Bolt, end-post (spare)
9	Bolt, riband, guardrail, "J"
2	Brace, sway, M2
14	Chess, M2
1	Frame, bracing
2	Pedestal, ramp, M2
5	Picket, steel
6	Pin, panel, short
6	Pin, safety
3	Pin, sway-brace (spare)
1	Plate, base
2	Post, end, female
2	Post, end, male
2	Ramp, button
4	Ramp, plain
2	Riband, guardrail, steel
2	Rope, lashing, 5/8"x25'

TRUCK LOAD #3 - DECKING LOAD

5	Bag, transport
20	Bolt, bracing
18	Bolt, riband, guardrail, "J"
6	Brace, sway, M2
28	Chess, M2
5	Raker
4	Riband, guardrail, steel
4	Stringer, button
6	Stringer, plain
6	Timber, packing, 2"x6"x4'-6"
2	Wrench, structural, 1-1/8"
2	Wrench, structural, 1-1/2"

TRUCK LOAD #4 - PANEL LOAD

11	Bag, transport
2	Bar, carrying
35	Bolt, bracing
15	Bolt, chord
4	Frame, bracing
2	Hammer, rawhide-faced
2	Panel
30	Pin, panel
20	Pin, safety
3	Plate, tie
2	Rope, lashing, 5/8"x25'
2	Wrench, socket, 1-1/8"
2	Wrench, structural, 1-1/8"
2	Wrench, structural, 1-7/8"

TRUCK LOAD #5 - TRANSOM LOAD

8	Bag, transport
2	Bar, carrying
50	Clamp, transom
20	Pin, safety
8	Transom, M2

TRUCK LOAD #6 - FOOTWALK LOAD

2	Bag, transport
40	Bearer, footwalk
16	Footwalk
40	Post, footwalk
2	Rope, handrail, 5/8"x150'
4	Rope, lashing, 5/8"x25'

TRUCK LOAD #7 - GRILLAGE LOAD

1080	Mat, airplane-landing, (sq ft)
72	Timber, grillage, 6"x6"x4'-6"

TRUCK LOAD #7A - SUPPLEMENTARY GRILLAGE LOAD

360	Mat, airplane-landing, (sq ft)
6	Ramp, plain
63	Timber, grillage, 6"x6"x4'-6"

TRUCK LOAD #8 - OVERHEAD BRACING LOAD

16	Bag, transport
60	Bolt, bracing
144	Bolt, chord
16	Brace, sway, M2
10	Frame, bracing
20	Support, overhead-bracing

TRUCK LOAD #9 - CRIB-PIER LOAD

20	Bag, transport
12	Bearing, crib
3	Bearing, junction-link
20	Bolt, bracing
6	Bolt, chord
6	Brace, sway, M2
6	Capsil, crib
2	Chess, junction, M2
26	Clamp, chord
24	Clamp, transom
3	Frame, bracing
3	Link, junction
4	Link, launching-nose, MkII
72	Pin, panel
100	Pin, safety
2	Pin, sway-brace, (spare)
6	Plate, tie
3	Post, junction, span, female
3	Post, junction, span, male
8	Raker

TYPES OF GRILLAGE NEEDED

BRIDGE **TYPE	SPAN (ft)	TYPES OF GRILLAGE: Safe Soil Pressure (tons per sq ft) 0.5	1.0	2.0	3.5
SS	30	5	4	1	*
	40	5	3	*	*
	50	5	2	*	*
	60	4	1	*	*
	70	4	1	*	*
	80	4	1	*	*
	90	4	1	*	*
	100	4	1	1	*
DS	50	7	6	4	1
	60	7	6	3	1
	70	8	4	1	1
	80	5	4	1	1
	90	5	4	1	1
	100	5	4	1	1
	110	5	4	1	1
	120	5	4	1	1
	130	5	4	1	1
	140	5	4	1	1
TS	80	7	6	4	3
	90	7	6	3	1
	100	8	4	1	1
	110	5	4	1	1
	120	5	4	1	1
	130	5	4	1	1
	140	7	4	1	1
	150	5	4	1	1
	160	7	4	2	1
	170	7	4	2	1
	180	7	4	2	1
DD	100	7	8	4	3
	110	7	6	4	3
	120	7	6	3	1
	130	7	4	2	1
	140	7	4	2	1
	150	7	4	2	1
	160	7	4	2	1
	170	7	4	2	1
	180	7	4	2	1
TD	110	7	8	4	4
	120	7	8	4	3
	130	7	8	4	2
	140	7	8	4	2
	150	7	8	4	2
	160	7	8	4	2
	170	7	8	4	2
	180	7	8	4	2
DT	130	7	8	8	5
	140	7	8	4	2
	150	7	8	4	2
	160	7	8	8	2
	170	7	8	8	2
	180	7	8	8	2
	190	7	8	8	2
	200	7	8	4	2
	210	7	8	4	2
TT	160	7	8	8	5
	170	7	8	8	5
	180	7	8	8	5
	190	7	8	8	5
	200	7	8	8	5
	210	7	8	8	5

* No grillage required under base plate or rocking-roller template.

** See TM 5-277 (1947) for types of grillage.

SAFE BEARING PRESSURE ON VARIOUS SOILS

DESCRIPTION OF SOIL	Safe bearing pressure (tons per sq ft)
SILTS and CLAYS (clay, silts, very fine sands, or mixtures of these.	
Soft muds or marshy soils...	0.5
Stiff silts or clays.....	2
Hard and dry clays.....	4
SANDS (sands and well-graded sandy soils)	
Very sandy soils and loose bank or beach sand.....	1.5
If grillage is buried 1½ feet	2.5
Cemented sands (soft sandstone)	5
GRAVELS (Gravel and well-graded gravelly soils containing some sand, silt, and clay)	
Bank gravel and well-graded gravelly soils.....	2
If grillage is buried 1½ feet	3
Compact gravelly soils or cemented gravels.....	6
ROCKS	
Poor quality rock, soft and fractured; also hardpan.....	5
Good quality rock; hard and solid	10 & up

NUMBER OF LOADS REQUIRED TO BUILD PANEL CRIB PIERS

PIER HEIGHT	PIER TYPE	TRK #1 ACCESSORY LOAD	TRK #4 PANEL LOAD	TRK #5 TRANSOM LOAD	TRK #9 CRIB-PIER LOAD
6'-6½"	DS(1H) TS(1H)	1 1	1 1	1 1	2 2
11'-3"	DS(1V) TS(1V)	1 1	1 1	1 1	2 2
11'-7"	DS(2V) TS(2V)	1 1	1 2	1 1	2 2
17'-0"	DD(2V-1H) TD(2V-1H)	1 1	2 2	1 1	2 2
21'-7"	DD(2V-1V) TD(2V-1V) DD(2V-2V) TD(2V-2V)	1 1 1 1	2 3 3 3	1 1 1 1	2 2 2 2
31'-7"	DT(2V-2V-2V) TT(2V-2V-2V)	1 1	3 4	2 2	2 2

LAUNCHING CONSTRUCTION

BRIDGE Type	Span (ft)	NO OF BAYS IN NOSE SS	DS	DD	Distance From Tip of Nose (ft)	Required Distance Behind Rocking Rollers (ft)
SS	30	2			—	35
	40	3			—	43
	50	3			—	47
	60	4			10	55
	70	5			20	63
	80	5			20	67
	90	6			20	75
	*100	*6			30	76
DS	50	3			—	45
	60	4			10	52
	70	4			10	57
	80	5			20	64
	90	6			20	71
	100	6			20	76
	110	7			30	83
	120	8			40	90
	130	8			10 & 40	95
	*140	*8			10 & 40	96
TS	80	5			20	63
	90	6			20	70
	100	7			30	74
	110	7			30	81
	120	8			40	86
	130	8			40	93
	140	9			10 & 40	100
	*150	*9			20 & 40	101
	*160	*9			20 & 40	106
DD	100	6			20	74
	110	7			30	81
	120	7			30	86
	130	8			30	93
	140	7	2		40	100
	150	6	3		40	106
	*160	*6	*4		10 & 40	112
	*170	*7	*3		10 & 40	113
	*180	*7	*3		20 & 40	117
TD	110	6			20	74
	120	7			20	84
	130	6	2		30	90
	140	8	2		30	96
	150	5	4		40	103
	*160	*5	*4		40	106
	*170	*6	*4		10 & 40	112
	*180	*7	*4		10 & 40	125
	*190	*7	*4		20 & 40	126
DT	130	5	3		30	91
	140	5	3		30	96
	150	5	4		40	102
	160	5	5		40	109
	*170	*5	*5		40	112
	*180	*5	*5		40	116
	*190	*6	*6		10 & 40	131
	*200	*7	*5		20 & 40	132
	*210	*7	*5		30 & 40	135
TT	*160	*5	*5		40	94 #
	*170	*5	*6		40	96 #
	*180	*6	*5	*2	40	102 #
	*190	*6	*6	*2	10 & 40	112 #
	*200	*7	*6	*4	20 & 40	112 #
	*210	*7	*5	*6	20 & 40	117 #

* Spans launched incomplete. See adjacent table.

\# Estimated.

SPANS LAUNCHED INCOMPLETE

Type	Span (ft)	No of Bays Decking & Stringers	Omitted of Top Story
SS	100	4	
DS	140	6	
TS	150	6	
	160	10	
DD	160	7	
	170	7	
	180	12	2
TD	160	3	
	170	10	
	180	All	3½
	190	All	
DT	170	3	
	180	8	
	190	All	5
	200	All	
	210	All	

No of Bridge Bays in Initial Construction [1]

160	3
170	6
180	6
190	14
200	14
210	14
160	14
170	14
180	14
190	14
200	14
210	13

First 3 bridge bays are constructed DT with only 1 transom per bay. Last bridge bay is constructed DT because of staggered construction necessary when adding subsequent bays.

NUMBER OF ROCKING ROLLERS NEEDED

Type	Span (ft)	Near Bank	Far Bank
SS	30 — 100	2	*
DS	50 — 80	2	*
	90 — 100	2	2
	110 — 140	4	2
TS	80 — 160	4	2
DD	100 — 130	4	2
	140 — 180	4	4
TD	110 — 120	4	2
	130 — 190	4	4
DT	130 — 210	4	4
TT	160 — 210	4	4

* Use two plain rollers.

WEIGHT PER BAY OF BRIDGES, NOSES, DECKING, AND OVERHEAD BRACING

CONSTRUCTION	WEIGHTS PER BAY (tons)
SS bridge *	2.93
DS bridge *	3.58
TS bridge *	4.18
DD bridge *	4.93
TD bridge *	6.05
DT bridge *	6.63
TT bridge *	8.46
SS launching nose	1.00
DS launching nose	1.84
DD launching nose	2.30
DECKING:	
Stringers only	0.79
Chess & steel ribands	0.66
FOOTWALKS	0.17
OVERHEAD BRACING (supports, transoms, sway bracing, & chord bolts)	0.54

* Footwalks included.

CRITICAL DIMENSIONS

Road width between steel ribands	12' - 6"
Lateral distance between center lines of trusses: inner trusses	14' - 10"
middle trusses	17' - 10"
outer trusses	19' - 3"
Lateral distance between center lines of base plates: S truss bridge	14' - 10"
D truss bridge	16' - 4"
T truss bridge	17' - 3½"
Lateral distance between outside edges of base plates: S truss bridge	19' - 5"
D truss bridge	21' - 10"
T truss bridge	21' - 10½"
Lateral distance between measuring lugs of rocking roller templates:	11' - 6½"
Lateral distance between measuring lugs of plain roller templates: SS, DS bridges	11' - 6½"
TS, DD, TD, DT, TT bridges	10' - 10½"
Height from base of base plate to top of chess	28-5/32"
Height from base of rocking-roller template to top of rocking roller	16-5/16"
Height from base of plain-roller template to top of plain roller	8-15/16"
Height from base of ramp pedestal to top of ramp chess	17-⅛"
Lateral distance between measuring lugs under sloping end of ramp to top of ramp chess	5-⅜"

NUMBER OF JACKS NEEDED AT EACH END OF BRIDGE

Type	Span (ft)	No of Jacks Needed At Each End of Bridge
SS	30 — 100	2
DS	50 — 140	4
TS	80 — 140	4
	150 — 160	6
DD	100 — 120	4
	130 — 180	6
TD	110 — 140	6
	150 — 190	8
DT	130	6
	140 — 180	8
	190 — 210	10
TT	160 — 170	10
	180 — 210	12

LAUNCHING TT BRIDGES:

1. Launch until near-bank rocking rollers are under last TT bay of initial construction.
2. Add up to 6 bays TT to tail of initial construction. This completes all but 210-foot span.
3. Continue launching until near-bank rocking rollers are under last TT bay added in step 2.
4. Add remainder of TT bays to complete bridge (210-foot span only).
5. Add 5 bays DS nose-type construction to tail of bridge.
6. Launch forward until first 3 DT bridge bays are beyond far-bank rollers.
7. Complete first 3 bridge bays by converting to TT and adding transoms.
8. Pull bridge back to final position, remove DS tail, add decking where needed, and jack down.

Table 2. Capacity of M2 Panel Bridge—Wheeled Vehicles

| WHEELED VEHICLES | WT-CLASS (TONS) | SS | | | | | | | | DS | | | | | | | | | | TS | | | | | | | | | | DD | | | | | | | | | | | | | | | | TD | | | | | | | | | | | | | | | | DT | | | | | | | | | | | | | | | | | | TT | | | | | | | | | |
|---|---|---

Table 3. Capacity of M2 Panel Bridge—Tracked Vehicles

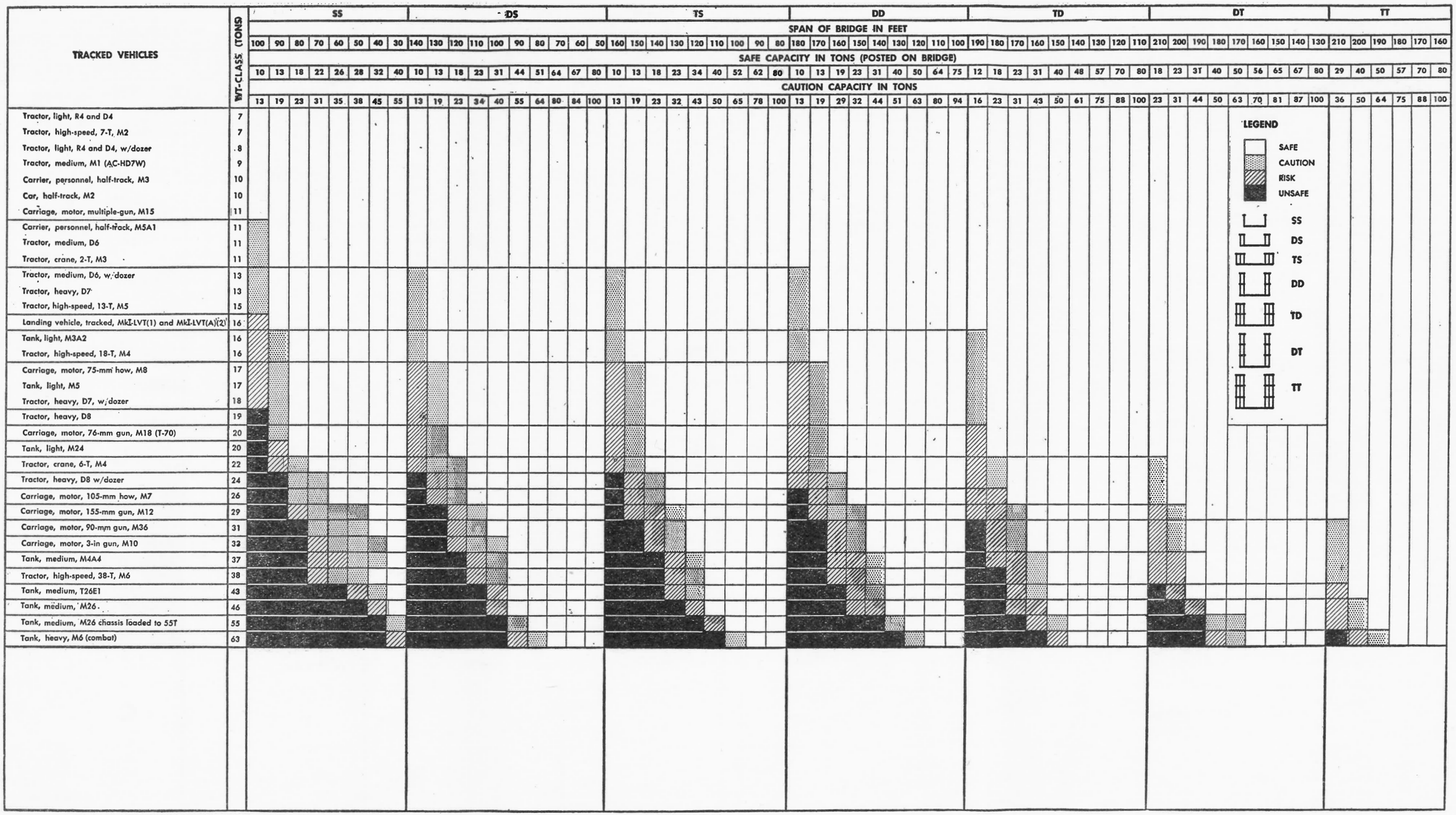


Table 4. Capacity of M2 Panel Bridge—Combination Vehicles

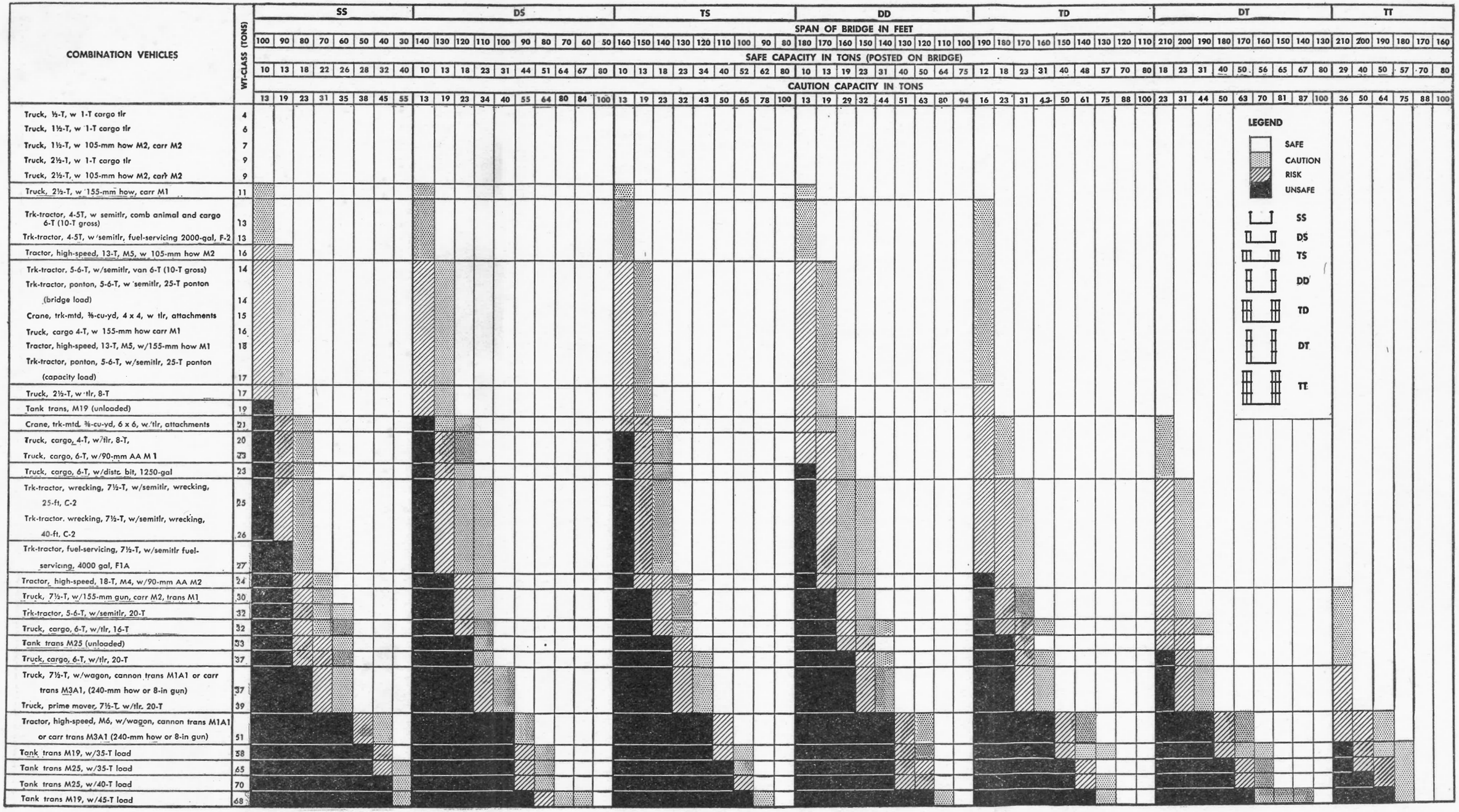


Table 27. Standard Truck-load Bridge Trains for M2 Bridges

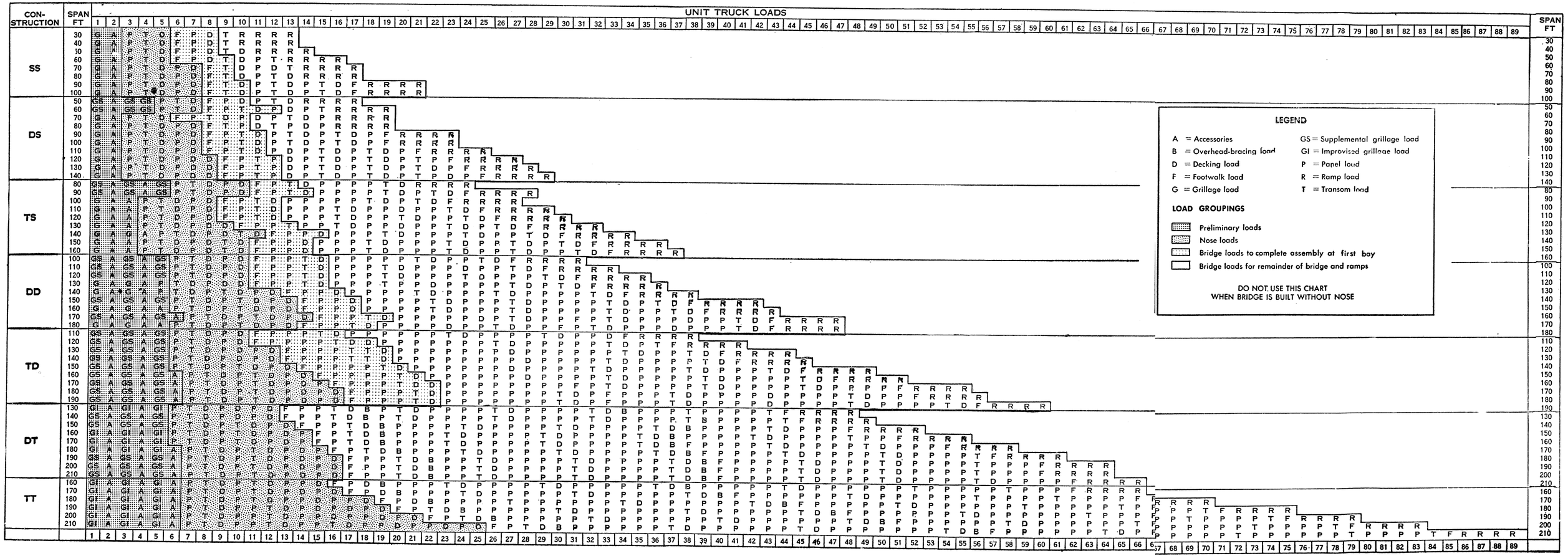


Table 55. Material Requirements of the Standard-Design Deck Type Panel Bridges

Item	Unit weight (lb)	Use	Single-story deck type bridge												Double-story deck type bridge									
			M2 panel bridge deck				Laminated timber deck				Layered timber deck				M2 panel bridge deck				Laminated timber deck				Layered timber deck			
			Interior bay		Two end bays		Interior bay		Two end bays		Interior bay		Two end bays		Interior bay		Two end bays		Interior bay		Two end bays		Interior bay		Two end bays	
			Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)	Number reqd	Total weight (lb)
Angle, 3″x3″x⅜″x24′–0″	173	Bracing for timber floor	.....	.....	.....	.....	2	346	5	865	2	346	5	865	.....	.....	.....	.....	2	346	5	865	2	346	5	865
Angle, 3″x3″x⅜″x29′–6″	212	Cross bracing	.....	.....	.....	.....	1	212	2	424	1	212	2	424	.....	.....	.....	.....	1	212	2	424	1	212	2	424
Angle, 3″x3″x⅜″x32′–6″	234	Cross bracing, M2 bridge	1	234	2	468	.....	.....	.....	.....	.....	.....	.....	.....	1	234	2	468	.....	.....	.....	.....	.....	.....	.....	.....
Bearing	68	End bearings	.....	.....	30	2,040	.....	.....	30	2,040	.....	.....	30	2,040	.....	.....	30	2,040	.....	.....	30	2,040	.....	.....	30	2,040
Bolt, ¾″x15″	2.18	Riband, laminated and layered floor.	.....	.....	.....	.....	8	18	20	44	8	18	20	44	.....	.....	.....	.....	8	18	20	44	8	18	20	44
Bolt, bracing	1	Bracing frames	40	40	40	40	40	40	40	40	40	40	40	40	80	80	40	40	80	80	40	40	80	80	40	40
Bolt, riband	1.5	Riband, panel bridge floor	16	24	32	48	.....	.....	.....	.....	.....	.....	.....	.....	16	24	32	48	.....	.....	.....	.....	.....	.....	.....	.....
Chess, M2	65	Floor, M2 bridge	26	1,690	52	3,380	.....	.....	.....	.....	.....	.....	.....	.....	26	1,690	52	3,380	.....	.....	.....	.....	.....	.....	.....	.....
Frame, bracing	43.6	On end verticals of panels	10	436	10	436	10	436	10	436	10	436	10	436	20	872	10	436	20	872	10	436	20	872	10	436
Nail, 40d	1/17	Wear surface	240	14	480	28	240	14	480	28	240	14	480	28	240	14	480	28	240	14	480	28	240	14	480	28
Nail, 60d	1/10.5	Timber floor	.....	.....	.....	.....	200	19	400	38	266	25	532	51	.....	.....	.....	.....	200	19	400	38	266	25	532	51
Panel	577	Trusses	15	8,655	30	17,310	15	8,655	30	17,310	15	8,655	30	17,310	30	17,310	30	17,310	30	17,310	30	17,310	30	17,310	30	17,310
Pin, panel, w/safety pin	6.21	Panels and end posts	30	186	90	559	30	186	90	559	30	186	90	559	60	372	60	372	60	372	60	372	60	372	60	372
Post, end, female	129.5	End of trusses	.....	.....	15	1,942	.....	.....	15	1,942	.....	.....	15	1,942	.....	.....	15	1,942	.....	.....	15	1,942	.....	.....	15	1,942
Post, end, male	121	End of trusses	.....	.....	15	1,815	.....	.....	15	1,815	.....	.....	15	1,815	.....	.....	15	1,815	.....	.....	15	1,815	.....	.....	15	1,815
Riband, steel	215	Curbs	4	860	8	1,720	4	860	8	1,720	4	860	8	1,720	4	860	8	1,720	4	860	8	1,720	4	860	8	1,720
Stringer, button	267	Floor	4	1,068	8	2,136	.....	.....	.....	.....	.....	.....	.....	.....	4	1,068	8	2,136	.....	.....	.....	.....	.....	.....	.....	.....
Stringer, plain	260	Floor	8	2,080	16	4,160	.....	.....	.....	.....	.....	.....	.....	.....	8	2,080	16	4,160	.....	.....	.....	.....	.....	.....	.....	.....
Timber, 3″x6″x12′–0″	52.5	Laminated floor	.....	.....	.....	.....	40	2,100	80	4,200	.....	.....	.....	.....	.....	.....	.....	.....	40	2,100	80	4,200	.....	.....	.....	.....
Timber, 3″x12″x10′–0″	87.5	Wear surface	16	1,400	32	2,800	16	1,400	32	2,800	16	1,400	32	2,800	16	1,400	32	2,800	16	1,400	32	2,800	16	1,400	32	2,800
Timber, 3″x12″x12′–0″	105	Bottom layer of layered floor	.....	.....	.....	.....	.....	.....	.....	.....	10	1,050	20	2,100	.....	.....	.....	.....	.....	.....	.....	.....	10	1,050	20	2,100
Timber, 3″x12″x17′–6″	153	Top diagonal layer of layered floor.	.....	.....	.....	.....	.....	.....	.....	.....	14	2,142	28	4,284	.....	.....	.....	.....	.....	.....	.....	.....	14	2,142	28	4,284
Transom, M2	618	Floor, M2 bridge	4	2,472	9	5,562	.....	.....	.....	.....	.....	.....	.....	.....	4	2,472	9	5,562	.....	.....	.....	.....	.....	.....	.....	.....
		Total weight (lb)	.....	19,159	.....	44,444	.....	14,286	.....	34,261	.....	15,384	.....	36,458	.....	28,476	.....	44,257	.....	23,603	.....	34,074	.....	24,701	.....	36,271
		(ton)	.....	9.6	.....	22.2	.....	7.1	.....	17.1	.....	7.7	.....	18.2	.....	14.2	.....	22.1	.....	11.8	.....	17.0	.....	12.4	.....	18.1

Table 60. Typical Railway Panel Bridges Built in ETO

Location	Kings Newton bridging school at Melbourne, Derby, England.	Railway bridging school at Rakha Mines, India.	Sicily	Ofanto River near Melfi, Italy.	Cevaro River near Foggia, Italy.	Durance River near Meyrargues, France.	Durance River south of Sisteron, France.	Durance River at Sisteron, France.	Montrond bridge over Buëch River at Serres, France.	Pont d'Ain bridge over Ain River near Poncin, France.	Suran River near Poncin, France.	Arbois, France	Doubs River at Dole, France.	Langley bridge over Moselle River near Charmes, France.
Span	90 feet	80 feet	120 feet (continuous over two 60-foot spans).	Three 60-foot spans	Three spans at 40 feet, 80 feet, and 40 feet.	170 feet continuous over two spans of 80 feet and 90 feet.	90 feet (continuous over two 40-foot spans and 10-foot wide pier).	60-foot span and 120 feet (continuous over two 60-foot spans).	40 feet (continuous over two 20-foot spans).	170 feet (continuous over two 85-foot spans).	90 feet	70 feet (continuous over two 35-foot spans).	460 feet (continuous over six 76½-foot spans).	450 feet (continuous over seven 64-foot spans).
Capacity	2–8–0 armored locomotive (equivalent to Cooper's E–35).	16 B.S.S. (equivalent to Cooper's E–35).	Not known	Class 70 (modified Cooper's E–40).	Class 70 (modified Cooper's E–40).	80-ton concentrated load string of 40-ton cars without locomotive.	Modified Cooper's E–40	Modified Cooper's E–40	Modified Cooper's E–40	Modified Cooper's E–40	Modified Cooper's E–40	Modified Cooper's E–40	Modified Cooper's E–40	Modified Cooper's E–40.
Number of trusses.	QD	QD	TD	TD—Deck in top story	TD—deck in top story	8 trusses grouped into two 4-truss girders.	6 trusses grouped into two 3-truss girders.	6 trusses grouped into two 3-truss girders.	4 trusses grouped into two 2-truss girders.	9 trusses	10 trusses	6 trusses grouped into two 3-truss girders.	10 trusses grouped into two 5-truss girders.	8 trusses.
Bracing	Normal	Normal	Normal	Normal	Normal	Bracing frames and tie plates.	Tie plates in each girder. Angle iron vertical cross bracing welded to panel verticals. Horizontal braces welded to bottom chords adjacent to panel verticals.	Bracing frames and tie plates—3-inch channel sway bracing welded under trusses.	Tie plates in each girder. Angle iron vertical cross bracing welded to panel verticals.	Bracing frames, tie plates, and modified transoms.	Bracing frames and tie plates. Angle iron sway bracing welded under trusses.	Tie plates in each girder. Angle iron vertical cross bracing welded to panel verticals. Horizontal braces welded to bottom chords adjacent to panel verticals.	Tie plates in each girder. 4-inch channel vertical cross bracing welded to panel verticals. 4-inch channel horizontal braces welded to top and bottom chords in each bay.	Bracing frames, tie plates, and transoms, 3-inch angle sway bracing welded under trusses.
Decking	Ties on two lines of rail clusters (3 rails in each cluster). Double transoms.	6″x8″x7′ ties at 1′8″ centers. Every third tie hook bolted to standard stringers. Outer stringers omitted. Double transoms.	Every 7th tie spiked to standard chess on stringers. Double transoms. Timber treads built up on each side of rails for highway traffic.	Ties at 2′6″ centers. Double transoms. Ties bolted every 10′ to plate under two transoms.	Ties at 2′6″ centers. Every fourth tie bolted to plate under transoms. Double transoms.	Ties at 2′6″ centers, chord bolted to trusses.	Ties at 16″ centers bolted to longitudinal timbers fixed to top chords of trusses.	Ties at 2′6″ centers bolted to trusses.	Ties at 16″ centers bolted to longitudinal timbers fixed to top chords of trusses.	Ties at 2′6″ centers, chord bolted to trusses.	Ties at 2′6″ centers, chord bolted to trusses.	Ties at 16″ centers bolted to longitudinal timbers fixed to top chords of trusses.	Ties at 2′6″ centers, chord bolted to trusses.	Ties at 2′6″ centers, chord bolted to trusses.
Bearings	Standard ends posts and bearings.	Standard end posts and bearings.		Standard end posts and bearings.	Standard end posts and bearings.	Rigid distributing beam under two node points seated on timber at abutments and piers.	Timber bearings	Underslung second story seated on timber at abutments. Steel rocker bearings on timber pier cap.	Timber bearings		Rigid distributing beam under two node points at each end. One end on steel plate for expansion.	Timber bearings	Steel distributing plate under two node points set on timber pier caps. Angle cleats for side guides.	Modified end posts at abutments. 8′9″ distributing beam under 3 node points over piers. Distributing beam rocks on standard bearings on greased steel plates between angle guides.
Construction time.				5 days	5 days	23 days	9 days	20 days (including 60-foot panel crib pier).	3 days		4 days		20 days	19 days.
Method of launching.				120 feet launched with 70-foot nose from one bank. 60 feet launched with tail from other bank.	120 feet launched with 70-foot nose from one bank. 40 feet launched from other bank.	Each 170-foot truss placed by high line. Bracing added after trusses were in place.	Entire bridge cantilevered into place.	60-foot and 120-foot trusses lifted directly into place by cranes.	Trusses manhandled into position.	Entire unit launched with 4-truss launching nose. Launching links between 2nd and 3rd bays. Bridge pulled across by winch. 16 jacks used to jack down.	Entire bridge launched with 4-truss launching nose. Bracing frames on top chord during launching only.	Entire bridge launched on rollers.	½ bridge cantilevered out from each bank. No launching nose. Pulled across by winch.	260 feet pulled by winch from one bank. 190 feet pulled from other bank. No launching nose used.
Figure reference.	183	184	185	186	186		187	188	189	182	178(6)	190	191	173 and 192.

Table 67. Abbreviations Used to describe Typical Panel Crib piers.

Type of pier								Abbreviation	Figure number
Number of trusses	Number of stories	Number of bays and panel positions							
		1st story	2d story	3d story	4th story	5th story	6th story		
Single	Single	One-horizontal						SS(1H).	
Double	Single	One-vertical						DS(1V)	232
Double	Single	Two-vertical						DS(2V)	219 and 243
Triple	Single	Two-vertical						TS(2V)	215 and 246(2)
Quadruple	Double	One-horizontal	One-vertical					QD(1H-1V)	239
Double	Double	One-vertical	One-vertical					DD(1V-1V)	232
Double	Double	Two-vertical	One-horizontal					DD(2V-1H)	234(2)
Double	Double	Two-vertical	One-vertical					DD(2V-1V)	236
Double	Double	Two-vertical	Two-vertical					DD(2V-2V)	218(2) and 245
Quadruple	Double	Two-vertical	Two-vertical					QD(2V-2V)	240
Triple	Triple	Two-vertical	Two-vertical	Two-vertical				TT(2V-2V-2V)	235
Double	Quadruple	Four-vertical	Four-vertical	Two-vertical	Two-vertical			DQ(4V-4V-2V-2V)	251 and 237
Triple	Five	Four-vertical	Four-vertical	Two-vertical	Two-vertical	Two-vertical		T5(4V-4V-2V-2V-2V)	237
Triple	Six	Two-vertical	Two-vertical	Two-vertical	Two-vertical	Two-vertical	Two-vertical	T6(2V-2V-2V-2V-2V-2V)	

Table 69. Equipment and transportation required to build standard panel crib piers

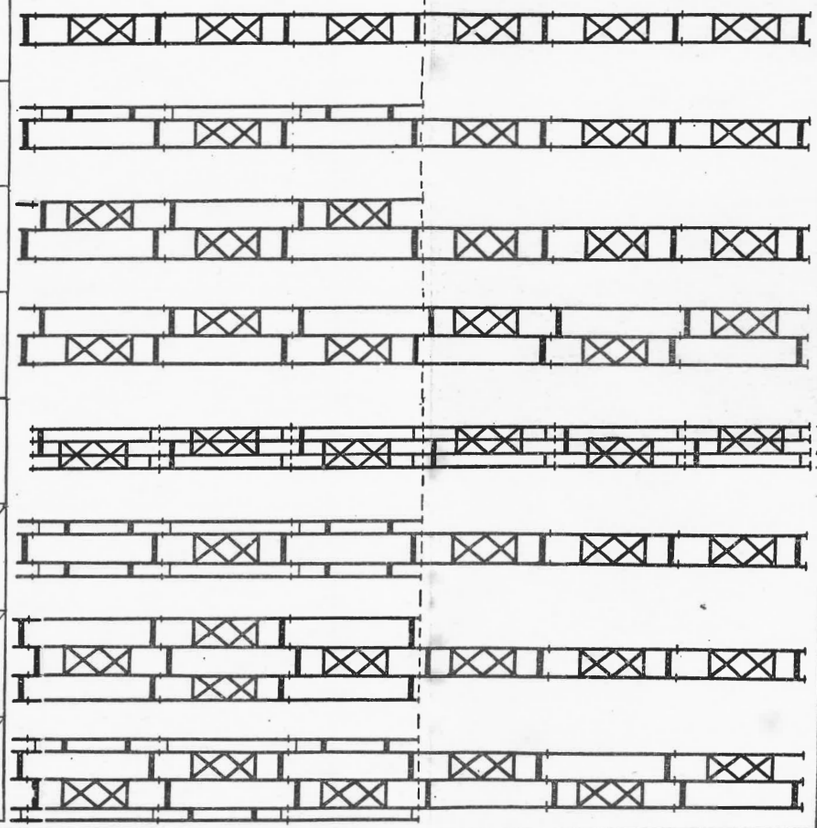
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				Figure reference																				
				230(1)	230(2)	231	232(1)		232(2)		233	234(1)		234(2)		235(1)			235(2)			236	237	
				Height																				
				6′–3½″	7′–2½″	6′–6½″	11′–2½″	21′–2½″	11′–3″	21′–3″	16′–6½″	16′–3½″	26′–3½″	17′–0″	27′–0″	10′–10½″	20′–10½″	30′–10½″	11′–7″	21′–7″	31′–7″	21′–7″	41′–7″	51′–7″
	Part	Unit weight (lb)	Basis for computing spares	Type of construction																				
				SS(1H) DS(1H) TS(1H)	SS(1H) DS(1H) TS(1H)	SS(1H) DS(1H) TS(1H)	SS(1V) DS(1V) TS(1V)	DD(1V-1V) TD(1V-1V)	SS(1V) DS(1V) TS(1V)	DD(1V-1V) TD(1V-1V)	SD(1H-1V) DD(1H-1V) TD(1H-1V)	SD(2V-1H) DD(2V-1H) TD(2V-1H)	DT(2V-2V-1H) TT(2V-2V-1H)	SD(2V-1H) DD(2V-1H) TD(2V-1H)	DT(2V-2V-1H) TT(2V-2V-1H)	SS(2V) DS(2V) TS(2V)	DD(2V-2V) TD(2V-2V)	DT(2V-2V-2V) TT(2V-2V-2V)	SS(2V) DS(2V) TS(2V)	DD(2V-2V) TD(2V-2V)	DT(2V-2V-2V) TT(2V-2V-2V)	DD(2V-1V) TD(2V-1V)	DQ(4V-4V-2V-2V) TQ(4V-4V-2V-2V)	D5(4V-4V-2V-2V-2V) T5(4V-4V-2V-2V-2V)
				Number of parts required[1]																				
1	Bearing[2]	68	....	2 4 4	.. .. ..	.. .. ..	2 4 4	4 4	.. .. ..	.. ..	.. .. ..	2 4 4	4 4	.. .. ..	.. ..	2 4 4	4 4	4 4	.. .. ..	.. ..	.. ..	.. ..	.. ..	.. ..
2	Bearing, crib	37	10%	2 4 7	.. .. ..	.. .. ..	2 4 7	4 7	4 9 13	9 13	.. .. ..	2 4 7	4 7	7 13 20	13 20	2 4 7	4 7	4 7	7 13 20	13 20	13 20	13 20	22 33	22 33
3	Bearing, junction-link	217	....	.. .. ..	2 4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	.. .. ..	.. ..	.. ..	2 4 6	4 6	4 6	4 6	4 6	4 6
4	Bolt, bracing	1	25%	10 10 20	10 10 20	10 10 20	.. 20 20	40 40	.. 20 20	40 40	.. 40 40	20 60 80	90 120	20 60 80	90 120	20 40 60	70 100	100 140	20 40 60	70 100	100 140	60 80	250 320	300 380
5	Bolt, chord	7.5	10%	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. ..	.. .. ..	.. ..	.. .. ..	4 9 13	18 26	4 9 13	18 26	4 9 13	18 26	26 40	4 9 13	18 26	26 40	9 13	70 106	79 119
6	Brace, sway, M2	68	10% to 4 max.	2 2 2	2 2 2	2 2 2	2 2 2	4 4	2 2 2	4 4	4 4 4	7 7 7	11 11	7 7 7	11 11	4 4 4	9 9	13 13	4 4 4	9 9	13 13	7 7	26 26	31 31
7	Capsill, crib	251	....	4 8 12	4 8 12	2 4 6	2 4 6	4 6	.. .. ..	.. ..	2 4 6	4 8 12	8 12	4 8 12	8 12	2 4 6	4 6	4 6	2 4 6	4 6	4 6	4 6	4 6	4 6
8	Chess, junction, M2	149	....	.. .. ..	.. .. ..	4 4 4	.. .. ..	.. ..	4 4 4	4 4	4 4 4	.. .. ..	.. ..	4 4 4	4 4	.. .. ..	.. ..	.. ..	4 4 4	4 4	4 4	4 4	4 4	4 4
9	Clamp, chord	11	10%	13 26 40	18 35 43	9 18 26	9 18 26	18 26	.. .. ..	.. ..	9 18 26	13 26 39	26 39	13 26 40	26 40	4 9 13	9 13	9 13	4 9 13	9 13	9 13	9 13	9 13	9 13
10	Clamp, transom	7	10% to 20 max.	4 9 13	4 9 13	4 9 13	4 9 13	13 20	4 9 13	13 20	9 15 24	13 24 37	33 51	13 26 40	33 51	9 18 26	26 40	62 92	9 18 26	26 40	62 92	26 40	106 158	123 185
11	Frame, bracing	44	10%	.. .. ..	.. .. ..	.. .. ..	.. 4 4	9 9	.. 4 4	9 9	.. 9 9	.. 9 9	13 13	.. 9 9	13 13	.. 4 4	9 9	13 13	.. 4 4	9 9	13 13	9 9	40 40	48 48
12	Link, junction	36	....	.. .. ..	2 4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	.. .. ..	.. ..	.. ..	2 4 6	4 6	4 6	4 6	4 6	4 6
13	Link, launching, Mk II[3]	28	....	.. .. ..	.. .. ..	2 4 6	.. .. ..	.. ..	2 4 6	4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	.. .. ..	.. ..	.. ..	2 4 6	4 6	4 6	4 6	4 6	4 6
14	Panel	577	10% to 10 max.	2 4 7	2 4 7	2 4 7	2 4 7	9 13	2 4 7	9 13	4 9 13	7 13 20	22 33	7 13 20	22 33	4 9 13	18 26	26 40	4 9 13	18 26	26 40	13 20	53 79	62 92
15	Pin, panel[4]	6	20% to 50 max.	24 48 72	29 58 86	34 67 101	24 48 72	58 86	26 53 79	62 94	38 77 115	31 62 94	82 122	58 115 173	134 202	19 38 58	58 86	77 115	46 91 137	110 166	130 194	101 151	187 281	206 308
16	Plate, base[2]	381	....	2 2 2	.. .. ..	.. .. ..	2 2 2	2 2	.. .. ..	.. ..	.. .. ..	2 2 2	2 2	.. .. ..	.. ..	2 2 2	2 2	2 2	.. .. ..	.. ..	.. ..	.. ..	.. ..	.. ..
17	Plate, tie	3.5	10%	 4	 4	 4	.. .. ..	.. ..	.. .. ..	.. ..	.. .. ..	 9	.. 13	 9	.. 13	 9	.. 13	.. 18	 9	.. 13	.. 18	.. 9	.. 31	.. 35
18	Post, junction, span, female	202	....	.. .. ..	.. .. ..	2 4 6	.. .. ..	.. ..	2 4 6	4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	.. .. ..	.. ..	.. ..	2 4 6	4 6	4 6	4 6	4 6	4 6
19	Post, junction, span, male	194	....	.. .. ..	.. .. ..	2 4 6	.. .. ..	.. ..	2 4 6	4 6	2 4 6	.. .. ..	.. ..	2 4 6	4 6	.. .. ..	.. ..	.. ..	2 4 6	4 6	4 6	4 6	4 6	4 6
20	Raker	22	10%	4 4 4	4 4 4	4 4 4	.. .. ..	.. ..	.. .. ..	.. ..	.. .. ..	9 9 9	13 13	9 9 9	13 13	9 9 9	13 13	18 18	9 9 9	13 13	18 18	9 9	31 31	35 35
21	Transom, M2	618	10% to 4 max.	2 2 2	2 2 2	2 2 2	2 4 4	7 7	2 4 4	7 7	4 8 8	7 8 8	10 10	7 8 8	10 10	4 4 4	7 7	15 15	4 4 4	7 7	15 15	9 9	26 26	31 31
	Load number	Name of load	Number of loads required																					
22	1	Accessory load	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1	1 1 1	1 1	1 1 1	1 1 1	1 1	1 1 1	1 1	1 1 1	1 1	1 1	1 1 1	1 1	1 1	1 1	1 1	1 1
23	4	Panel load	1 1 1	1 1 1	1 1 1	1 1 1	1 2	1 1 1	1 2	1 1 2	1 2 2	3 4	1 2 2	3 4	1 1 2	2 3	3 4	1 1 2	2 3	3 4	2 2	6 9	7 10	
24	5	Transom load	1 1 1	1 1 1	1 1 1	1 1 1	1 1	1 1 1	1 1	1 1 1	1 1 1	2 2	1 1 1	2 2	1 1 1	1 1	2 2	1 1 1	1 1	2 2	1 1	3 3	4 4	
25	9	Crib-pier load	1 2 2	1 2 2	2 2 2	1 1 1	1[5] 1	2 2 2	2 2	2 2 2	1 2 2	2 2	2 2 2	2 2	1 1 1	2 2	2 2	2 2 2	2 2	2 2	2 2	4 4	5 6	

[1] Quantities include spares as indicated in third column.
[2] These parts not supplied in loads needed to build pier. Use extras from bridge construction.
[3] Used for launching only. Removed after bridge is in place.
[4] Does not include pins for launching links Mk II when used.
[5] Add 2 extra bracing frames to this load.

Table 80. Composition of Launching Noses and Launching Weights of Multi-truss Girders

Type of girder	Spacing of outer trusses 315	Type of nose	Number of bays in nose / Launching weight in tons (No / Wt) — Span (feet) [1]								Figure reference
			40	50	60	70	80	90	100	110	
Double-truss	1′-6″	Double-truss	4 / 5.0	5 / 6.4	6 / 7.6	7 / 8.8	8 / 10.2	9 / 11.4			
Triple-truss	2′-2½″	Double-truss[2]	4 / 6.2	5 / 7.8	6 / 9.3	6 / 10.3	7 / 11.8	8 / 13.4			322
Triple-truss	3′-0″	Double-truss[2]	4 / 6.3	5 / 8.0	5 / 8.9	6 / 10.5	7 / 12.0	8 / 13.7			323
Triple-truss	3′-0″	Triple-truss	4 / 7.6	5 / 9.6	6 / 11.4	7 / 13.4	8 / 15.2	9 / 17.2			
Four-truss	2′-2½″	Four-truss	4 / 9.9	5 / 12.4	6 / 14.8	7 / 17.3	8 / 19.8	9 / 22.3	10 / 24.8		
Four-truss	2′-11″	Double-truss	3 / 6.8	4 / 8.6	5 / 10.6	6 / 12.4	6 / 13.6	7 / 15.5	8 / 17.4	9 / 19.2	321
Four-truss	4′-6″	Double-truss	3 / 7.0	4 / 8.9	5 / 10.9	6 / 12.8	6 / 14.1	7 / 15.9	8 / 17.9	9 / 19.8	324
Five-truss	4′-5″	Triple-truss	4 / 10.0	4 / 11.6	5 / 14.1	6 / 16.6	7 / 19.2	8 / 21.6	8 / 23.2	9 / 25.7	325

PLAN VIEW



[1] Longer spans cannot be launched by this method because of insufficient lateral stability.
[2] Remove nose as each bay clears far-shore landing rollers.

KEY

- Panel
- Bracing frame on top of panels
- Bracing frame on end of panels
- Tie plate on top of panels
- Tie plate on end of panels

Table 90. Types of Grillage Needed for M1 Bridge

Construction	Safe soil pressure (tons per sq ft)	Span in feet																		
		30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
SS	0.5	5, 7, 8	5 to 8	5 to 8	5 to 8	4 to 8	4 to 8	4 to 8	4 to 8											
	1.0	4 to 8	4 to 8	3 to 8	3 to 8	1 to 8	1 to 8	1 to 8	1											
	2.0	1 to 8	1 to 8	[1]	[1]	[1]	[1]	1 to 8	[1]											
	2.5	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]											
	3.5	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]											
DS	0.5	.....	.....	7	7	7	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	4, 5, 7, 8	4, 5, 7, 8							
	1.0	.....	.....	6, 7, 8	6, 7, 8	5 to 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8	2, 4, 5, 6, 7, 8						
	2.0	.....	.....	4 to 8	3 to 8	3 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8						
	2.5	.....	.....	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8						
	3.5	.....	.....	1 to 8	1 to 8	[1]	[1]	[1]	[1]	[1]	1 to 8	1 to 8	[1]	[1]						
TS	0.5	.....	.....	.....	.....	7	7	7	7	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8	5, 7, 8					
	1.0	.....	.....	.....	.....	7, 8	6, 7, 8	6, 7, 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8	4 to 8					
	2.0	.....	.....	.....	.....	4 to 8	4 to 8	3 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8					
	2.5	.....	.....	.....	.....	3 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8					
	3.5	.....	.....	.....	.....	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8	1 to 8					
DD	0.5	.....	.....	.....	.....	.....	.....	7	7	7	7	7	7	7	7	7	[2]	7			
	1.0	.....	.....	.....	.....	.....	.....	7, 8	7, 8	6, 7, 8	6, 7, 8	4 to 8	4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8			
	2.0	.....	.....	.....	.....	.....	.....	6, 7, 8	4 to 8	4 to 8	3 to 8	2 to 8	2, 3, 4, 5, 7, 8	2, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 4, 5, 7, 8			
	2.5	.....	.....	.....	.....	.....	.....	4 to 8	3 to 8	1 to 8	1 to 8	1 to 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8			
	3.5	.....	.....	.....	.....	.....	.....	1, 2, 4, 5, 6, 7, 8	1 to 8	1 to 8	1 to 8	1 to 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8			
TD	0.5	.....	.....	.....	.....	.....	.....	.....	.....	7	7	7	7	7	7	7	7	7	7		
	1.0	.....	.....	.....	.....	.....	.....	.....	.....	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	4, 7, 8	4, 7, 8	7, 8		
	2.0	.....	.....	.....	.....	.....	.....	.....	.....	7, 8	4, 7, 8	4, 5, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 7, 8		
	2.5	.....	.....	.....	.....	.....	.....	.....	.....	5, 7, 8	4, 5, 7, 8	3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 4, 5, 7, 8	2, 4, 5, 7, 8	2, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 4, 5, 7, 8		
	3.5	.....	.....	.....	.....	.....	.....	.....	.....	1, 2, 5, 7, 8	1, 2, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8		
DT	0.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	7	7	7	7	7	7	7	7
	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8	7, 8
	2.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7, 8	7, 8	7, 8	7, 8	4, 7, 8	4, 5, 7, 8	4, 7, 8	4, 7, 8	4, 7, 8
	2.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5, 7, 8	5, 7, 8	7, 8	7, 8	4, 5, 7, 8	3, 4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8	4, 5, 7, 8
	3.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2, 5, 7, 8	2, 5, 7, 8	2, 5, 7, 8	2, 5, 7, 8	2, 3, 4, 5, 7, 8	1, 2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8	2, 3, 4, 5, 7, 8
TT	0.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[2]	7	7	7	7	
	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[2]	7	7, 8	7, 8	7, 8	
	2.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	7, 8	7, 8	7, 8	7, 8	
	2.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	7, 8	7, 8	7, 8	7, 8	
	3.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5, 8	5, 7, 8	5, 7, 8	2, 5, 7, 8	2, 5, 7, 8	

[1] No grillage required.
[2] Use improvised grillage.